School Science and Mathematics

VOL. V. NO. 2 FEBRUARY, 1905 WHOLE NO. 31

DESIRABLE PRODUCT FROM THE TEACHER OF MATHEMATICS—THE POINT OF VIEW OF AN ENGINEERING TEACHER.*

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The school curriculum of to-day lies under the charge, vigorously pressed at the hands of many, of leaning to fads and being given over to poor teaching. The teaching of only two subjects seems to be excepted from the general charge of incompetency that is often made,—namely, Latin and Mathematics;—and I have sometimes reflected upon the meaning and propriety of the exceptions. Returning to these reflections when your courteous Secretary invited me to address you, I determined to lead you over some of this ground,—old and often trod ground you may say,—but nevertheless it is ground well worthy of surveying again and even again.

I think the charge of fads grows partly or wholly out of the character of work done in the kindergartens,—under which name numerous sins are often cloaked by well meaning, accomplished, but highly impractical, and often incompetent, teachers. I am an earnest believer in the purposes of the kindergarten, but the practical results of its operation, where I have observed it, seem often to disseminate faulty methods of observation, poor workmanship in handicrafts, and inaccuracy in thought. It is suggested that the pure kindergarten methods have their most important place in connection with the schools of social settlements and their like, which are found in the most densely settled portions of cities, and which have to do with children who find little or no

* An address delivered before the general session of the Central Association of Science and Mathematics Teachers, Nov. 25, 1904.

of the gentle or softening influence of the average American home. These methods certainly bring a minimum of good to children of whom reasonable obedience and courteous bearing are expected in their home life.

To the kindergarten belongs the initial work of manual training. By that often abused phrase I particularly mean geometrical drawing and instruction in handicrafs of various kinds. Indeed, a relatively large proportion of the kindergarten pupil's time ought to be engrossed by manual training, because the brain is then specially amenable to training in the precise control of the senses; and this manual training ought to be carried up through the grades in the elementary schools with gradually decreasing allotment of time until it is nearly (or even entirely) succeeded by purely mental studies when the high school is reached. All that is now done with manual training in the high schools can be better done in the lower schools. But brains can be as easily produced by wishing, as precision of thought and act can be produced by an untrained teacher.

There is the rub in the situation. Poorly taught manual training is particularly dangerous because it encourages lack of precision in perception, performance and judgment, at the very time in his development when the habit of slovenly inaccuracy is most readily impressed upon the pupil. Less harm from poor teaching in this branch results in the high school than in the kindergarten, because the older child is less readily and less permanently affected by slovenly processes, if he has previously been under wise instruction. Also, better teachers, with reasonably good training, are available for the high school teaching of manual training, because better wages are there afforded. How can we expect—who should expect,—accuracy of observation, precision of act, and accuracy of thought to be inculcated in small children by a young woman who possesses not one of those important attributes herself, and who has never learned that they are important—indeed, essential—to the highest success in man or woman?

Gentlemen of the secondary schools, if you will lend your attention judiciously to reforming the schools below yours, and will really produce the reformation, you will be relieved of that disconcerting and mischievous pressure that is now directed

towards securing for manual training a considerable portion of the time of the secondary school curriculum which is now occupied by what are commonly called disciplinary studies.

A few of the better universities acknowledge that a small amount of manual training is appropriate to the list of entrance requirements, and such an acknowledgement is quite usual by the engineering colleges (the University of Wisconsin admits not to exceed 1 unit out of the 14 units of high school work accepted for entrance into engineering courses). Such a proportion is substantially as much as ought to be made a part of the high school curriculum, but it ought to be only the final capping of a stout pyramid of drawing and handicrafts which has its capacious lower leaf in the primary school or kindergarten. In this connection, let me say that much confusion exists in the minds of many regarding the relations of trades schools to high schools and of trades schools to university courses in engineering. Each of these has its own place, and they should not be confused.

Precision of observation, accuracy of execution and clear reasoning are necessary to the best endeavor in all disciplinary studies, but particularly in mathematics. These attributes may be built up with peculiar success when the aid of rightly conceived and *wisely taught* manual training is invoked during the tender years of the pupil. But even when these attributes are possessed by all of your pupils, the fullest success in teaching mathematics will still demand a fixed purpose and high pedagogical ideals in the teacher, added to a sympathetic knowledge of his subject.

A *man* is a creature who honestly brings his undertakings to accurate results, even though the method adopted may not be the simplest or the one approved by academic authority. This requires an open mind, keen observation, analytical thinking, and accurate powers of inference.

A parrot might glibly recite the rules for following an approved method, and then defend inaccurate results by the plea of carelessness, or haste in the particular instance.

The *man* may not know the rules as they are phrased in the books, but an inaccurate result is (for him) a matter of real chagrin and humiliation.

As the pupils now come to the colleges (perhaps I should refer more particularly to engineering colleges, as with them my experience more particularly lies) from the secondary schools, initiative, regard for accuracy, or understanding of continuous initiative, regard for accuracy or understanding of continuous intellectual effort. It is true that they are not yet mature in either body or mind, and too much should not be expected of them. But it is also true that their preparatory schooling has left them with a defective acquaintance with the construction of the English language and the spelling of English words, a still more defective acquaintance with French or German or a fairly good grounding in elementary Latin, a smattering of Civics and History, a training in the elementary principles of Arithmetic, Geometry and Algebra, *from which the factor of accuracy in application has often been omitted,* and perhaps an enthusiastic though often misguided interest in the physical sciences.

I do not wish you to think of me as reflecting on the industry of the secondary school teachers. The facts are as I have stated them, but I can truthfully say that, considering all of the conditions, there is probably no more painstaking and right wishing body of people than these teachers. It is the conditions that are not right. The schools encourage, as Herbert Spencer says, "*submissive receptivity* instead of *independent activity*." The unfortunate situation is perhaps a result of the inexperience of school boards, or the inexperience, inadequate compensation, or improper training of a large proportion of the teachers, or the crowding of the schools may overwork and cramp the best of teachers.

Many of the faults in the secondary school training (which has been the lot of students entering our engineering colleges) may be caused by a doubt that has recently seemed to unsettle certain educational. circles on account of the question whether high schools shall be the "peoples' colleges," or remain in the station of secondary schools. This doubt is apparently not yet resolved in the minds of those who undertake to mould educational thought in the secondary schools; but the traditional old-time secondary school training which produced men who could spell and cipher and who had received a thorough and accurate drill in at least one language is certainly to be given foremost

place as a preparation for a college course. In my estimation, when accompanied with history and a year spent in civics and natural science, it is not only an advantageous school course for preparing students for college, but it is a preferable course for those numerous young people who cannot go through college.

Many of the errors of teaching in the universities are the result of an undiscriminating chasing after the popular cry, and many spurious pedagogical ideas are still propagated which were long since laid by the competent leaders. I presume that the same condition is found in the secondary schools. What engineering teacher can do his duty who does not understand the truly simple relation between theory and practice, and where can he find it better expressed than when reading the inaugural dissertation of Professor Rankine! What secondary school teacher can teach his best, whatever may be his instinctive capacity, who has not read Montaigne's essays on teaching or Spencer's little book on Education, or who has not absorbed the point of view of some of the great teachers through adequate biographies?

Of the elementary mathematics taught in the schools, I have just said that the factor of accuracy in application is often omitted, or, if it is not actually omitted, it is largely neglected.

Contact with men entering college shows that:

The arithmetic class is taught the rules, but not the reasoning upon which the rules are founded or the overshadowing importance of impeccable accuracy in numerical results.

The algebra class is taught to transform (or, as I may call it, juggle) equations, but little thought is bestowed where the greatest thought belongs,—that is, to the physical meaning of each form that is produced. This fault I must admit is not missing from the universities, and is propagated in the schools by association.

The geometry class is apparently taught by rote, and even where a show is made of encouraging the originality of the pupils, it is likely to be more an illusion than a fact.

Large classes encourage teaching for the average mass, rather than the stirring of each individual, as must be done to create the fullest results. Apparently in few mathematics classes are the pupils taught to scrutinize and check the results of their labors

by means appealing more to the common sense than to cut and dried methods. Many years of observation with college students has shown me that the attention of secondary school pupils is seldom drawn to such useful processes for checking numerical results (which were taught with fidelity to our fathers) as "casting out the nines;" and, the worst of it is, that the pupils have not been taught even the simple philosophy of our decimal system which might enable them to work out the processes for themselves.

If the causes that contribute to allow the pupils to reach the end of the secondary school training with their originality sleeping, their normal sense of accuracy lost, and their best accomplishment in mathematics a parrot-like following of hackneyed method in familiar problems,—if the causes from which these conditions spring are anchored in over-crowded classes, then it is your duty and privilege to cry aloud for more air, more breath of life, more chance to teach each living individual instead of the average of an inert class.

Mathematics is a tool—a powerful system of logic, an aid to reasoning—which confers power and advantage on the individual in proportion to the fullness of his possession. The value of mental discipline obtained while accomplishing that possession is inestimable. And the teacher's aim ought to be to make that possession most complete in those respects which stimulate the powers of accurate (straight) reasoning.

It has seemed to me that the present teaching of mathematics is not so effective as that brought to bear on my generation in the secondary schools, and it likewise appears to me that my generation was less effectively taught to reason, through mathematics, than was my father and his generation.

I am not a reactionary or one who exalts the past before the present. But I see a reason for the present condition in the extended introduction of analytical mathematics and a consequent relegation of constructive mathematics to a minor place. The introduction of the analytical mathematics is not of itself to be regretted, but it seems to have brought with it a change in the method of teaching which is profoundly unfortunate. The teacher now feels under requirement to lead a large class over certain

ground in a given time, and (to use the concrete example of algebra) he finds he may do so by expecting the students to learn the processes by the book, and solve the equations, but he has no time (nor strength, if the class is unduly large) to spend in the work which is really of overshadowing importance,—that is, drilling the students to interpret the physical meaning of each pregnant transformation.

Unhappily this condition has had the support of the science departments (especially of mathematics and physics) in some of our great universities, where it has been held that the equation is the thing and the interpretation of minor moment; and with this support in high quarters, how should we expect the stupefying mechanical method to be banished from the secondary schools?

But, gentlemen, *the equation is not the thing.* The interpretation of the equation,—an understanding of the real meaning of transformations, and a grasp of the relations of things, which lead to sound reasoning,—are the features of first importance to be derived from the study of mathematics.

The mental subsoil is stirred in developing physical conceptions of the relations of things, while even the sod may not be well broken in learning the processes of juggling equations. Stirring the mental depths often calls for the exertion of the utmost powers of good teaching, but poor teaching is inexcusable, unless, much easier as it is, it may be exacted by the undermanned and overcrowded conditions of some of our schools.

What constitute first rate instincts in a teacher of mathematics may be illustrated by an anecdote:

Some years ago a mature graduate student who was in one of my college classes asked me if it would not be better to go slower at some places so that the class should *thoroughly understand the relations of things,* even if we did not cover the whole subject in the allotted time. This was text book work and in an engineering subject of analytical character. We were then covering only 10 or 12 duodecimo pages per day, but the book was one in which nearly every sentence was charged with important meaning and each mathematical expression, however simple or complicated, represented some important physical relations.

That student had been a college instructor with a fine reputa-

tion as a teacher of mathematics or mechanics and since then he has become a professor of engineering. I have understood that he has strongly entrenched his reputation as a man whose students become young men of discreet thought, notable for resourcefulness and character.

What we need from the mathematics teacher is: not for them to produce young men who can juggle equations, but to produce young men *who can recognize the relations of things.*

My limit of time is presumably exhausted, and I will conclude. You probably will not all now agree with my opinions, but fair opinions honestly spoken ought to offend no one; and I am satisfied that my opinions will be sustained in the minds of the majority of experienced teachers in engineering colleges who have given careful thought to the question before us. When the University of Wisconsin puts into effect a year hence its promulgated additional requirements in algebra preparation for students entering the College of Engineering, it is not so much because we particularly care for more pages of the book to be covered in the high schools, but because we hope that the students (with more time allotted to the subject) may attain more of the true powers of reasoning that come from searching for and recognizing the relations of things.

If a teacher's pupils are capable of transforming (juggling) equations correctly according to rule, without giving a thought to the meaning of the forms produced, or are capable of following through an arithmetical problem by the approved method without considering too reasonable accuracy of the numerical results, then that teacher's sowing has been choked with tares. But a teacher of mathematics who leads his pupils to give due thought in the course of their work to interpreting equations, to noticing the relations of things, and to scrutinizing and checking the accuracy of every numerical result (even though the pupils may evolve, for their own use, awkward and unapproved analytical methods),—that teacher's sowing is of golden wheat.

SIMPLE EXPERIMENTS IN HYGIENE.

By Lillian Chapin,
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Hygiene is the one secondary school subject that every pupil will find necessary throughout life. Yet, in few high schools and normal schools has it received the treatment a subject of such importance demands. This article is a plea for definite, forceful experiments and demonstrations in this subject, comparable with the experiments and demonstrations so long deemed essential in physics and chemistry. The following are experiments of this nature that could be carried out in any secondary school.

1. *To demonstrate bacteria in the air.* If it were possible to find a transparent solid substance upon which germs would multiply, this substance might be exposed to the air and bacteria allowed to settle on it. On multiplying, there would develop about each bacterium, a group, or colony of bacteria, which colony might, in time, become large enough to be visible to the naked eye. Several such "culture media" have been devised by bacteriologists. The one selected for this work was nutrient agar, a jelly-like material made from sea-weed.* This medium is conveniently stored in test-tubes, each containing enough for a single experiment. For the work here reported about 5 c. c. of melted agar was placed in each tube. The tubes were plugged with cotton and rendered free from living organisms by heating in a steam sterilizer.

The only other article needed for this experiment is a flat glass dish with a glass cover, the so-called Petri dish. A number of these dishes were cleaned, dried, and heated in an oven to render them free from living germs.

A test-tube of agar was melted by immersing it in boiling water. The agar was then poured out into a Petri dish where it soon solidified in a thin layer. The cover of the dish was now removed and the agar exposed to the air for a number of minutes. The cover was replaced and the dish set aside to develop. Two days later, it contained 63 colonies of bacteria, while a Petri dish

*For methods of making and sterilizing media, see any text-book of Bacteriology.

prepared in the same way but not exposed to the air developed no colonies.

2. *To demonstrate bacteria in water.* A test-tube of agar was melted and then placed in water at 42° C., a temperature slightly above that of the human body. At this temperature, agar remains liquefied, but is not hot enough to kill bacteria. Two tiny drops of drinking water, each less than a millimeter in diameter, were transferred to this liquid agar by means of a small loop of platinum wire. The agar was then poured into a sterile Petri dish. The dish was put aside and a few days later was found to contain fourteen colonies of bacteria, each colony representing a bacterium present in the original drops of water.

3. *To demonstrate bacteria in milk.* In the same way, two tiny drops of milk were inoculated into agar and the agar poured into a Petri dish. In this dish 192 colonies developed.

4. *To determine the effect of heat upon bacteria.* Three test-tubes of milk were taken. The first was kept at room temperature, the second was immersed in water heated to 60° C., and the third was placed in boiling water. At the end of about twenty minutes, tiny drops were taken from each sample and Petri dishes prepared in the manner described above. The number of colonies developing on each of these dishes is shown below:

Unheated milk	192 colonies
Milk heated to 60° C.	13 colonies
Milk heated to 100° C.	5 colonies

In the process of pasteurization, milk is heated to 60° C. for half an hour. This is sufficient to kill all the more common disease germs, but not sufficient to kill some of the more resisting, harmless bacteria.

5. *To determine the effect of freezing on bacteria.* Two test-tubes of water were taken. One was kept at room temperature. The other was immersed in a freezing mixture of salt and ice and frozen solid. At the end of twenty minutes it was removed from the freezing mixture and allowed to melt. Petri dishes were then prepared from each with the following counts:

Not frozen	272 colonies
Frozen	294 colonies

In a similar experiment performed with milk, 192 colonies developed from the sample kept at room temperature, and 193 colonies from the samples frozen.

From these experiments, we see that bacteria are probably unaffected by ordinary freezing, the differences noted above being presumably due to variations in the size of the drops taken.

6. *To show the effect of temperature on the rate of multiplication of bacteria.* Three test-tubes of milk were taken. A Petri dish made from the milk at this time showed 80 colonies of bacteria. The first was placed in an ice chest, the second was kept in a locker, and the third was put in a thermostat at 37°C. The next day Petri dishes were made from each tube, with the following results:

Ice chest (4°C.)	70 colonies
Locker (20°C.)	30,000 "
Thermostat (37°C.)	100,000 "

7. *To determine the effect of drying on bacteria.* Three tiny drops of beef broth in which typhoid fever germs * were growing, were transferred to each of two dry, sterile test-tubes. Into the first tube, melted agar was poured, and then poured out into a sterile Petri dish. The drops in the second tube were allowed to dry, and two days later a Petri dish was prepared from this tube in the same way. In the first dish 6,000 colonies grew. No colonies developed from the dried specimen.

Drying kills many disease germs, but some of them, e. g., the tubercle bacillus, can resist drying for a long time.

8. *To determine the effect of sunlight on bacteria.* Two slips of filter paper were wet with a beef-broth culture of typhoid bacilli. The papers were placed in dry test-tubes. The test-tubes were sealed with paraffine to prevent drying. One of the tubes was placed in a locker. The other was exposed to sunlight for three hours. The papers were then removed, dropped into tubes of melted agar, and the agar poured into Petri dishes. From the paper kept in the locker, 100,000 colonies developed. No colonies grew from the paper exposed to sunlight.

*In repeating this experiment in high schools, harmless germs must of course be used. The colon bacillus is recommended for this purpose.

9. *A study of antiseptics.* Four test-tubes were prepared, each containing 5 cc. of water to which typhoid bacilli had been added. To the first tube nothing was added. To the second tube ½ cc. of a weak solution of the antiseptic to be tested was added. To the third, 1 cc., and to the fourth 2 cc. Twenty minutes later, Petri dishes were prepared from each of these tubes. The number of colonies developing in each is shown below:

Antiseptic	0 cc.	½ cc.	1 cc.	2 cc.
5% Carbolic acid	446	237	95	20
95% Alcohol	446	96	25	1
Salicylic acid (Sat. sol.)	3640	298	60	15
1-10% Mercuric Chloride	3640	1	0	0

10. *To disinfect a room.* Three slips of filter paper were moistened in a beef-broth culture of typhoid bacilli. These were placed in sterile test-tubes, and the test-tubes in turn were placed in large glass jars. In the first jar sulphur was burned. Into the second jar, formaline vapor, generated by heating commercial formaline in a distilling flask, was passed. The third jar was not treated with a disinfectant. A few hours later, Petri dishes were prepared from each paper. The results are shown in the table below:

No disinfectant	100,000	colonies
Sulphur fumes	6	"
Formaline vapor	0	"

11. *To show the effect of food preservatives on the rate of multiplication of bacteria.* Two test-tubes, each containing 5 cc. of fresh milk, were taken. A Petri dish made from the milk at this time showed 83 colonies of bacteria. To one of the tubes a grain or two of common salt was added. To the second tube nothing was added. The next day, Petri dishes were made from these tubes with the following results:

No preservative	7,520	colonies
Salt	850	"

12. *To show the antiseptic properties of gastric juice.* An artificial gastric juice was prepared by dissolving a little pepsin in

a ¼% solution of hydrochloric acid. To 1 cc. of this juice, ¼ cc. of a beef-broth culture of typhoid bacilli was added, and Petri dishes made from the mixture at intervals for half an hour. The number of colonies developing on these dishes is tabulated below. To get an idea of the number of germs originally added to the juice, the same amount of typhoid culture was added to 1 cc. of sterile water and a Petri dish prepared from this mixture. The number of colonies on this dish is recorded as the count for 0 minutes.

0 minutes	 35,200	colonies
2 "	 157	"
15 "	 3	"
30 "	 0	"

13. *To show the antiseptic properties of human serum.* Under the supervision of a physician, a small amount of blood was drawn, by means of a hypodermic needle, from a vein in the arm. This blood was placed in a sterile glass vessel and allowed to clot. After standing some time, serum separated. One cubic centimeter of this serum was placed in a small test-tube and five loops full of a beef-broth culture of typhoid bacilli were added to it. Petri dishes were made from this mixture at intervals for an hour. To get an idea of the number of germs originally placed in the serum, a control was run with an equal volume of sterile water. The count made from this control is recorded as the count for 0 minutes.

0 minutes	 3,760	colonies
2 "	 737	"
8 "	 410	"
15 "	 34	"
30 "	 2	"
60 "	 0	"

14. *Are bacteria given off from a moist surface?* A culture of harmless, brilliant yellow bacteria was smeared on the inside of a large glass tube. Through this tube, a strong current of air was directed onto agar in a Petri dish. If bacteria were given off into the air from the moist culture, they would be blown upon the

agar, where they would develop into colonies. The Petri dish used in this experiment developed no yellow colonies.

The smear was allowed to dry and was then crushed with a sterile glass rod. A second current of air was now directed through it into another Petri dish. This dish developed 240 colonies of yellow bacteria.

Bacteria are not given off into the air from a moist surface. Tuberculous sputum and other infectious materials are, therefore, comparatively harmless while in a moist condition. The breath of a consumptive is free from germs. This, of course, does not mean that in coughing, or in excited speech, germs may not be thrown into the air in the form of spray.

The above are suggestions of the kind of experiments that might be done with profit in secondary schools. Most of these experiments can be performed by the average high school senior. All of them can be used as class demonstrations. A few weeks' training in bacteriological technic will enable any teacher to give this work.

These experiments require only the simplest apparatus; a few test-tubes, Petri dishes, and a little platinum wire. A steam sterilizer, which need not cost over $1.25, is the most expensive single article.

I am indebted to Dr. W. H. Manwaring, of the Department of Pathology and Bacteriology of the University of Chicago, for suggestions in regard to a number of these experiments.

COMPARISON OF THE FUNDAMENTAL OPERATIONS.

By Fannie Webster,
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The word mathematical is considered almost a synonym for exact, accurate; and a mathematical definition should be so exact, so accurate that that which is bounded by it can be clearly distinguished from all else. That the definitions of the fundamental operations are not so carefully made is evident in examining any of the ordinary text-books. Such statements as "Subtracting a positive quantity is the same as adding a negative quantity of the same absolute magnitude" show that a clear distinction is not made between two dissimilar operations. There is the same confusion in multiplication and division; dividing by a fraction is

considered the same thing as multiplying by the reciprocal of the fraction.

The purpose of this article is to show that well-defined lines can be drawn, so clear that a child can see them, so true that the most learned may accept them as correct boundaries.

A stake was five feet from the center of a field and was moved three feet; how many feet was it then from the center? A problem in addition. An arithmetical solution would assume the same direction and say $5+3=8$. An algebraic solution would need to know the direction and would say $5+3\ (-1)^n$, any number of feet from 8 to 2 inclusive. (n representing any number, integral, fractional, incommensurable, positive, negative, zero, or imaginary.)

If the temperature is 50° above zero and changes 10°, the resulting temperature will be found by addition, $50°+10°$, 60° above, or 40° above, according to the character of the change.

If the latitude of a city is 25° N. and another city is 40° south of it, the latitude of the second is found by addition. 25° N.+ 40° S, $+25+{}^{-}40=15{}^{-}25++40=+15$ according to the direction chosen as positive.

In addition we start from a given point and travel a given distance in a given direction and find the terminal point of our journey. We would come back by *adding* the same distance in the opposite direction, and so reach the starting point.

A stake was five feet from the center of a field and was moved to a point eight feet from the center; how many feet was it moved? A problem in subtraction. Considering it algebraic, and therefore including direction, the solution would be $8-5(-1)^n$, any number of feet from 3 to 13 inclusive.

That is, in subtraction we know the point to be reached and find how far and in what direction we must travel to reach it. Subtraction finds the distance between two points, the difference between two values, what must be added to one to produce the other.

Although $7+2=9$ and $7-{}^{-}2=9$, subtracting negative 2 from positive 7 is a very different operation from adding positive 2 to positive 7. In subtracting we find how far it is in the scale of

numbers from $^{-}2$ to $^{+}7$ and find 9 units of difference. In addition, we start at $^{+}7$, move 2 units in a positive direction and find that we have reached the point $^{+}9$. That we obtain the same number in one case as in the other arises from the facts that adding the same number to both minuend and subtrahend will not change the difference between them; by adding 2 to both, the subtrahend becomes zero so that instead of $7 - {}^{-}2$ we have $(7+2)-0$, that is $9-0$; and a number is determined by its distance from zero.

A barrel contains a gallon of water; if we put b gallons in or take b gallons out, the resulting amount would be found by addition $a + \pm b = c$. If we wish to find what would change the amount in the barrel to c gallons, it would be $c - a = \pm b$.

Moving up the scale, down the scale or off the scale in any direction for any distance is addition. Finding how far and in what direction we go from point to point is subtraction. These two operations are based entirely upon a change of zero. We know the distance of the first number from the primary zero and the distance of the second from the first (considered as zero) to find the distance of the second from the primary zero. In subtraction we know the distance of each from the primary zero to find the distance of the second from the first (considered as zero).

In multiplication, as in addition, a number is found from knowing how it compares with a given number, but now the given number is considered a secondary unit, not a secondary zero and it is a question of *times,* or *part,* or *opposite,* or any other relation that a quantity could bear to the unit of measurement.

In multiplication the relation is given and one term of the comparison to find the other term.

In division both terms are given and the relation is to be found.

$$\$5 \times 3 = \$15 \qquad \$15 \times \tfrac{1}{3} = \$5$$
$$\$15 \div \$5 = 3 \qquad \$5 \div \$15 = \tfrac{1}{3}$$

In addition and subtraction the unit is fixed and the zero varies; in multiplication and division the zero is fixed and the unit varies. In multiplication we know how the product compares

with the multiplicand considered as a unit and find how it compares with the primary unit. In division we know how dividend and divisor compare with the primary unit and find how the dividend compares with the divisor as a unit.

In involution, also, a number is found from knowing its relation to another number. Now the relative places of the two numbers in a series of powers is compared. Whether we want the fourth term in a series of powers in which 3 is first term, $3^4=81$; or the first term where 25 is second, $25^{1/2}=5$; or the second we know the relation and find the second term of the comparison the process is involution, but *finding* $log_3 81$, $log_{25} 5$, *or* $log_8 1/4$ *should for the sake of consistency be called evolution.*

Then we would have from our three modes of comparison: comparison by difference, comparison by ratio, comparison by logarithms, the three direct operations and the three reverse operations quite distinct from each other. In addition, multiplication, and involution the relation and one term given to find the other term; in subtraction, division, and evolution, the two terms given to find the relation. Reversing the terms would reverse the *relation* but not the *evolution.*

RECENT ADVANCES IN METEOROLOGY.*

BY HENRY J. COX, A. M.,

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Mr. President, Ladies and Gentlemen of the Convention, and I hope I may say "Fellow Forecasters," as I am confident that you all have had more or less experience in forecasting the weather.—The first forecaster concerning whom I have any definite recollection was my instructor in freshman physics at Harvard in the early 80's. During one of the lectures our tutor, to whom we had applied the name of "Bobby," was describing a *wonderful* instrument called the mercurial barometer. It seems that the barometer was at the time very low on account of the

* An address delivered before the Earth Science Section of Central Association of Science and Mathematics Teachers, Nov. 26, 1904.

passage of a rainstorm over eastern Massachusetts. Bobby informed the class that the mercury in the barometer had just begun to rise,—a sure indication, he said, that the rain would soon end and that the clouds would clear away before night. It was still raining when the class met again two days later. Of course an explanation was in order and our instructor blushingly informed us "how it happened"—something I have had to do myself occasionally during my professional career. It seems that a second rainstorm followed immediately in the wake of the first one, permitting the barometer to rise only slightly. It soon afterwards began to fall again, and the rain was practically continuous.

I shall speak today more especially of the advances made in meteorology that have a particular bearing upon weather forecasting. The practical side of the science is the forecast work, and the question is often asked, "Is any improvement being made in the forecasts?" To this we can safely answer, "Yes." But that improvement is due only in a slight measure to any advance recently made in the science of meteorology.

HISTORICAL REVIEW.

The different weather services throughout the world have been passing through the various periods of evolution, and no Bureau that has any claims to a scientific basis has felt this process any more than the Weather Service of the United States. Founded as it was in 1870 as a part of the Regular Army Signal Corps, officered for more than twenty years by men who as a rule had little sympathy with its work, and containing in its rank and file observers who were permitted to have no initiative, although many of them were college graduates, the wonder is that any progress was possible in this country during the army period. The army officers came and went, and though a few possessed skill in forecasting and evinced some knowledge of meteorology, the best of them left scarcely anything behind to assist their successors. I venture the statement that when the National Weather Service was transferred to the Department of Agriculture in 1891, no book or paper of value upon the science of forecasting was turned over to the men who were to form the scientific staff of the Bureau at Washington.

Fortunately, during the army regime, a corps of civilian professors was attached to the central office, and these men did much to keep alive the spirit of investigation in higher meteorology, but they were seldom permitted to engage in forecasting. That branch of the work was performed mainly by the army officers. Among the professors, we find two names well known to us all, Abbe and Ferrel. Professor Abbe is "our grand old man" in meteorology. He did more than any other person to bring about the original beginning of the Weather Service, and it is a pleasure to know that he is still with us. Abbe has been a consistent contributor to the literature of higher meteorology, but he is best known as the editor of the Monthly Weather Review. Those of you who read the publication will appreciate the work he is doing. He has ever been conservative, and possibly rather slow to venture along such lines of investigation as solar physics, believing as he does that our studies should be confined to the dynamics of the earth's atmosphere. Prof. Ferrel remained with the Government service but a few years. His investigations into the general and secondary movements of the atmosphere are well known to the scientific world. His popular Treatise on Winds has been widely used as a text and reference book, and Professor Davis has drawn upon it freely in the preparation of his own well known work on meteorology.

SUCCESS IN FORECASTING.

Strange as it may seem, men of the highest scientific attainments and possessed of profound knowledge in higher meteorology, have never been distinguished as forecasters. Our best forecast officials have usually been men of only moderate education, some of them not even having a University degree. They have generally been close students of the forecast charts and mindful of characteristic types as outlined upon the maps, possessed of sound judgment and able to think quickly. Considerable advancement has been made in the forecasts since 1891—the year the Weather Bureau was transferred to the Department of Agriculture,—but it has been due chiefly to the improvement in the personnel of the forecasting staff and the longer experience of the men. With the exception of Professor Bigelow's work,

to which reference will be made later, recent researches both at home and abroad, have served but little to advance the empirical science of forecasting. In a word the basic principles are nearly the same now as they were 10 or 20 years ago. The forecasters, however, are better trained and they give more attention to detail, and undoubtedly make much better predictions. It is not many years ago that the prognostications were made only for large sections, which were designated as Upper Lake Region, Lower Lake Region, Upper Mississippi Valley, etc., etc. Later, the various states were specified, and now our present organization ventures forecasts even for single cities. During the winter season special predictions are also made as to the probable minimum temperature locally during the ensuing night, in order to assist shippers of perishable goods and transportation companies to protect the freight from injury. We now forecast for 36 and 48 hours in advance instead of 24 hours as formerly. In fact we endeavor to do more for the public, and more and more is expected of us. There has of course been much progress made in theoretical meteorology, but the results of the investigations have in a few instances only been of assistance to the forecaster.

ASTROPHYSICS AND ITS BEARING UPON METEOROLOGY.

The present organization of the Weather Bureau under its able chief, Prof. Willis L. Moore, is keeping step with the progress of the times, and in research work our staff in Washington is forging ahead of the advances made in Europe. There is now great activity both at home and abroad in the study of Astrophysics, although all meteorologists are not agreed that the subject properly belongs to our science. However, sufficient connection between the activities of the sun and the terrestrial atmospheric changes seems to have been established to warrant meteorologists to enter upon the field of Cosmical Meteorology. Professor Abbe's ideas upon this subject can best be expressed in his own words. I quote from the Monthly Weather Review of June, 1901: "As the periodicities in sun spots, the width of the spectrum lines, the magnetic and auroral phenomena are sufficiently well marked to be satisfactorily demonstrable, while corresponding variations in pressure, temperature, wind and rainfall

are small, elusive and debatable, we must caution our readers against being carried away by optimistic promises. It is certainly impressive to the thoughtful mind to realize that there is even a slight connection between solar and terrestrial phenomena, but the delicacy of this connection is such that it still remains true that the study of meteorology is essentially the study of the earth's atmosphere as acted upon by a *constant source of heat* from the sun. None of these astrophysical studies should tempt the meteorologist to wander far from the dynamics of the earth's atmosphere and the effects of oceans and continents that diversify the earth's surface."

On the other hand, Professor Bigelow, who joined the Weather Bureau staff in 1891, is an enthusiastic student of Cosmical Meteorology and is a firm believer in the sun's causation of atmospheric phenomena. Bigelow is bold and fearless in attacking various problems that have been presented, and some of his theories have evoked severe criticism from European investigators. He has been working for many years in the field of astrophysics with the hope of establishing some relation between solar and terrestrial variations. While it is self-evident that the temperature of our atmosphere depends absolutely upon the solar radiation, Bigelow would have us believe that the connection between solar energy on the one hand and the variations in atmospheric pressure as well as temperature has already been established. Many believe that the investigations will ultimately furnish the basis for long range seasonal forecasts and afford material assistance in short range forecast work.

Direct connection between sun spots and atmospheric changes has not been satisfactorily determined. No terrestrial cycles have been found corresponding to the 35-year and 11-year sun spot cycles, except possibly those of terrestrial magnetism and the aurora. Discussion of the spots is being replaced by others upon the solar prominences and faculæ, which apparently respond much more exactly to the working of the sun's internal circulation. Bigelow believes that the observations prove that the terrestrial temperature changes with the variations of solar prominences. Dr. J. Hann in his Lehrbuch der Meterologie writes: "Further

observations can lead to the discovery of the period, but it is very difficult to find the true length, since the amplitude of the variation of the meteorological elements within the year is not very great, because so many other influences are present, which stand in the way of deriving more accurate mean values out of long intervals of time. As yet no one has succeeded in surely deducting a cyclic variation of considerable magnitude." Dr. Sprung agrees with Bigelow to some extent, as does also Lockyer, who has been working along the same lines. But no one here or abroad has dared to venture as far as Bigelow, who has investigated the variations in temperature, clouds, rainfall, thunderstorms, hail, barometric pressure, cyclones and winds especially with a view of finding at first an 11-year period synchronous with that of the sun spots, and later a shorter period of about three years corresponding to the prominence curve. Bigelow believes that he has established a direct relation at least between this curve and the temperature and pressure observations in certain parts of the earth, while in other parts the synchronism is of the inverse type. Dr. Sprung says in his Lerhbuch, "A connection between the sun spot frequency and the change in our atmosphere cannot well be denied. It is probable that the periodic changes in the atmosphere are not caused directly by the sun spots, but that both phenomena are brought about through one common or by several interacting causes, whereby a displacement of the periods relative to one another becomes possible."

SOLAR ACTIVITY AND TERRESTRIAL MAGNETIC STORMS.

Terrestrial magnetic storms have generally been considered due to solar activity, yet Father Cortie of the Observatory at Stonyhurst, England, shows in the Astrophysical Journal for November, 1902, that several magnetic storms occurred during periods of absolute solar quiet and often most active sun spots have been unaccompanied by magnetic storms. Cortie is of the opinion that the magnetism is purely terrestrial and that there is no connection between solar spots and terrestrial magnetism. He cites two important instances, one of fine spots without any magnetic disturbance, and the other of the greatest magnetic disturbance without any accompanying spots which seem to him to dis-

prove any connection of cause and effect between the phenomena. He further states that at periods of maximum solar and magnetic activity, the storms are often so mixed up, one with the other, that it is extremely difficult to assign individual magnetic disturbances to their solar concomitants.

Professor Nippoldt of Potsdam, replying later in the Astrophysical Journal, claims that Father Cortie has not submitted sufficient proof for his conclusions. Nippoldt believes that even if there appeared to be no connection between these phenomena at Stonyhurst or Potsdam, there might be a relation in higher latitudes or in places near the poles. Great solar activity is usually accompanied by terrestrial magnetic storms, but the exceptions referred to by Cortie cannot well be explained.

There is also some disagreement as to the time it takes the sun to rotate on its axis, but it is almost the general concensus of opinion that the period at the equator is 26.69 days. Evidences of cycles corresponding to this period have been looked for, but the synchronism has not been established. The results of the studies into this branch of solar physics are not yet considerable, but persistent and consistent investigation may ultimately bring forth exact knowledge.

THE SOLAR CONSTANT.

A study of the solar contsant and the absorption of solar radiation within the earth's atmosphere is now being actively pursued by many scientists. Professor Langley, Secretary of the Smithsonian Institution in Washington, has probably gone farther into this line of research than any other American investigator. He led an expedition to Mount Whitney in 1881, for the purpose of securing observations on the summit of a mountain, where he expected to avoid the disadvantages that usually must be met with in the lower atmosphere. Langley's report upon these observations may be found in Signal Service Professional Papers No. 15. The results of his later studies, which are being carried on at the Smithsonian Astrophysical Observatory in Washington, have appeared from time to time in Nature and the Astrophysical Journal. The solar constant is the amount of solar radiation received outside the earth's atmosphere, all of which would practically

reach the surface of the earth, did not the terrestrial atmosphere exist. In order to determine the constant, the effects of atmospheric absorption must in theory be eliminated, since only after the actual interposition of this do we receive the heat. It is practically impossible to secure measurements that are absolutely exact, but the relative values are very important. Langley believes that a chief cause of possible variability of solar radiation is in the solar envelope itself, as we receive heat and light through different thicknesses of it. The variability of our own atmosphere largely interferes with our study of the sun. Langley measures the total radiation by the actinometer, and the intensity of the homogeneous rays in different parts of the spectrum for different altitudes of the sun by the bolometer. From these direct observations he calculates in theory the total absorption of the atmosphere of the several rays under the varying conditions, but on account of the constant fluctuation of the atmosphere the absorption is continually changing, and it is difficult to discriminate between any change due to it and that due to an actual change in the radiation of the sun itself. Langley estimates that with the actinometer it is possible to secure relative values of the total solar radiation at the earth's surface within 2 percent, but that the absolute results may not be within 20 percent of the truth. He therefore concludes that the values secured should not be regarded as absolute measures of the solar radiation, but only as forming a series comparable among themselves, from which all known terrestrial variations are excluded and which may furnish evidence of a suspected variability of the so-called solar constant. Langley has taken as a provisional value of the solar constant, 2.54 gram calories per sq. centimeter per minute, and later investigations impressed him with the belief that it was sufficiently large. In fact, his maximum during 1903 was only 2.28 calories in February, and this fell to a minimum of 1.93 calories in August. His observations also show a falling off in the transparency of the atmosphere in 1903 and this tended to reduce the intensity of the violet end of the spectrum. Very little change in the clearness of the atmosphere alters decidedly its transparency for some wave lengths. In the morning hours the transparency of

the air increases rapidly and sometimes irregularly, while in the afternoon it continues longer of nearly uniform and maximum transparency. The greatest measurement is reached shortly after noon. Of course, it is more difficult to secure values of the solar constant at stations near sea level than at high altitudes. Mr. Abbott of the Smithsonian Institution, in discussing the diminished transmissibility of the atmosphere during 1903, in the Monthly Weather Review for December, 1903, attributes the loss to the large amount of volcanic dust in the air, and Mr. H. H. Kimball of the Weather Bureau and other investigators agree with him. There were numerous volcanic eruptions in 1902, and the explanation seems reasonable. However, no satisfactory explanation of the possible variation of the solar constant can be given at the present time.

Mr. Kimball has been using a pyrheliometer at Asheville and Black Mountain, N. C., to measure the solar radiation, and later in Washington, and his observations show a small value in insolation in 1903 as compared with 1902, and a similar discovery was made by M. Dufour in his measurements at Lausanne, Switzerland. Relatively similar results were obtained by the observatory in Warsaw, Russia, and at other points in Europe. Dufour calculated that the average radiation through a cloudless sky during January, February and March, 1903, was from 14 to 21 per cent less than the average of these months for the years 1897 to 1902, inclusive. Kimball's observations during certain months in 1903 indicated a falling off in radiation of about 16 per cent as compared with 1902, while Langley concludes that there was a loss in transmissibility in 1903 as compared with 1902 and 1901 of 20 per cent for the green rays, but diminishing for rays of greater wave length, and averaging about 10 percent for all rays. The temperature during the greater portion of the year 1903 was low over the entire north temperate zone, and a connection between the insolation and the terrestrial temperature has apparently been established. If it develops that there is a secular variation in the quantity of solar radiation received at the outer surface of the earth's atmosphere, we shall certainly wish to study such variations in connection with the

occurrences of sun spots, solar prominences and terrestrial magnetism that are now known to exist, and it will be in order to trace the connection between such variations and seasonal departures from normal weather conditions. The results of the studies in this field of astrophysics seem to justify us in the belief that we may ultimately find some basis for making seasonal long range forecasts. I believe that we are working in the right direction, but progress is certain to be slow, as the immensity of the task is well nigh appalling.

EXPLORATIONS OF THE UPPER AIR BY MEANS OF KITES, BALLOONS, ETC.

Meteorologists and forecasters have long realized that they have been working at great disadvantage, in having complete observations of surface conditions only. An effort was made by the United States Weather Bureau in 1898 to secure data from the upper air by means of box kites equipped with meteorographs. Seventeen kite stations were established, well distributed throughout the country, but the experiments were abandoned after a period of six months, as the expected uniformity in the work was not realized. The light winds during the summer months prevented flights from being made regularly at all stations, a velocity of 12 miles per hour being required to raise the kites. Nevertheless, information was obtained concerning the vertical temperature gradients over a wide area of the country up to a height of 8,000 feet, as well as data relative to humidity and wind movement and direction. The Blue Hill Observatory, near Boston, Mass., took up the investigation and it has sent up kites as high as three miles. A systematic exploration of the atmosphere above the continent of Europe has been in progress for several years under the direction of an international committee. Manned balloons and balloons carrying recording instruments only have been used in addition to the kites in the experiments abroad, but it frequently happens that the wind at the ground is insufficient to raise the kites. Moreover, as the balloons drift with the upper currents to considerable distances, the comparison of the data obtained from them with observations made at designated stations on the ground is more or less uncertain.

It is possible to make only brief reference to these observations in this paper. Those of the Weather Bureau indicated a mean rate of decrease of temperature with increase in altitude of 5 degrees for each 1,000 feet. The largest gradient, 7.4 degrees per thousand feet, was found in the first thousand, the rate generally diminishing with the altitude. The morning gradients were much less than in the afternoon. An inversion of temperature was often found in anti-cyclones, especially to the west of their centers, and a very pronounced condition of this character was usually followed within two or three days by a well marked warm wave. There was generally a steady decrease in temperature with altitude during cyclonic conditions, and the diurnal variations diminished with the height and disappeared within two miles of the ground, while a cold wave was found to be confined to a thin stratum near the earth.

The relative humidity was found to vary considerably in the different strata, sometimes increasing and other times decreasing with the altitude, but there was not much difference in the mean values obtained.

(*Continued in March number.*)

AN EXPERIMENT TO SHOW THE GAIN IN WEIGHT OF SULPHUR BURNING IN AIR.

BY DELIA M. STICKNEY, ASSISTED BY WM. L. KIEMAN.

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The apparatus is identical with the one often used to show the gain in weight of a burning candle.

A cylinder of copper gauze is filled with pieces of caustic soda and fitted tightly into the top of a student lamp chimney; by a wire attached to the gauze the whole may be suspended from the arm of a balance. Into the lower part of the chimney is fitted a cork stopper with sections cut from the circumference half way to the center, so as to allow free passage of air up through the apparatus. On the cork is placed a sulphur candle, which may easily be made as follows: Sulphur is melted in a test tube to amber

state and poured into a paper box three-fourths inch square, while a short piece of lamp wick is held in the center. The sulphur hardens quickly and burns easily. Any small paper or paste-board box is suitable, but one is easily made by folding stiff brown paper in the desired shape.

When the whole apparatus is balanced, the candle is lighted and in three minutes enough surphur dioxide has been absorbed by the caustic to make the arm bearing the candle fall. It may be balanced again without extinguishing the light, and the experiment repeated four or five times without change of apparatus.

This is a simpler experiment that the one with the candle, as the sulphur is an element. It is of value in the beginning of chemistry, since it shows the gain in weight in the case of a gaseous product, a much more difficult task than the determination of gain when the product of combustion is a solid.

THE INFLUENCE OF THE TEACHER'S RESEARCH WORK UPON HIS TEACHING OF BIOLOGY IN SECONDARY SCHOOLS.*

JOHN M. COULTER.

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I take it for granted that this subject has been selected for discussion because it represents a real question among you. If it is a real question, your experiences and your predispositions are arrayed on both sides of it. My own experience in reference to the teaching of biology in secondary schools can count for little on either side of the question. My predisposition is entirely in favor of the general proposition that research improves a teacher. And yet I recognize the fact that college or university teaching, from which all of my teaching experience has been derived, is necessarily very different from teaching in secondary schools. In fact, I am sure, from my own observation, that a serious blunder is often made when a university graduate attempts to duplicate

* An address delivered before the Biology Section of the Central Association of Science and Mathematics Teachers, Nov. 25, 1904.

university courses and university methods in the secondary school. Such courses and methods in general are not adapted to the age of the pupil or to the recitation period of the secondary school.

Therefore, I do not propose to discuss this question upon the presumption that it is a question of introducing university methods into secondary schools; for from my point of view this is not an open question. The question, as it lies in my mind, is whether research work makes a better teacher of biology for secondary schools, with all their limitations. It is conceded freely that it makes a better university teacher; and I know of no better way of attacking the subject than to discover in what respects research work makes a better university teacher, and then to judge whether these same things would also be of advantage to a teacher in the secondary schools.

There must be further limitations to the discussion, so far as I am to present it, for the teachers now teaching biology in secondary schools easily fall into three categories, and to only one of them does the discussion apply.

1. *Those who are not teachers.*—Like in every other discussion dealing with a teacher's methods or equipment, we recognize in this one that if all teachers were "born" teachers our discussions would be largely over or would deal with minor points, for the most fundamental thing would be settled. I believe fully in the doctrine of the absolute autonomy of the born teacher, and am everlastingly opposed to any organization that cripples or even handicaps the freest possible expression of his ideas. But unfortunately there are far more positions than there are such teachers; and so our troubles begin, and our discussions become necessary. Biology has fared no better than other subjects, and it has its share of teachers who are not teachers. It is hardly necessary for me to describe the earmarks by which they may be recognized; for if you are a teacher you have recognized them already; and if you happen to be one of the other class, not even a diagram would make your classification clear to you.

There are numerous university instructors who are not teachers, but justify their positions by being strong in research and useful in guiding it. But no secondary school would be justified

in retaining this type of instructor; for in secondary schools the first quality demanded is the ability to teach.

It is evident, therefore, that if the secondary school instructor is no teacher to begin with, no amount of research work is going to make him a better one. What he needs is to be "born again." In fact, I believe that if an instructor is not a teacher, research work will make him a worse one in secondary schools; for it must be recognized that in research work there are developed certain tendencies inimical to elementary instruction, and it takes the real teacher not to be lead astray by them.

We cannot test this question by sweeping all teachers into the same category. If you point out successful and unsuccessful teachers of biology as illustrations that absence of research work makes a successful teacher and research work makes an unsuccessful one, it is probably more fundamentally true that your successful teachers are real teachers and your unsuccessful ones are not. Such illustrations are very deceptive unless they are all reduced to sea-level and a real comparison made possible.

I think it is evident, therefore, that teachers who cannot teach should not be included in this discussion.

2. *Teachers who cannot do research work.*—These are real teachers, but they do not possess what we call the investigative faculty. It is not a question of relative ability with them, but of actual possession. In university work it does not take long to differentiate good students into two classes: those who can be trained to become investigators; and those whom no amount of training will make investigators. This represents a difference of mental constitution, that is discreditable to neither. The good student, who is not an investigator, has unusual capacity for acquisition, and if he has also teaching ability he has the power of clear and attractive presentation. Such a student is a star in recitation; but when put face to face with a problem there is no initiative. He can travel the beaten path, but he cannot break through the thicket. He belongs to civilization and not to pioneer conditions. Usually it takes a long time to convince such a one that he is not an investigator. He is put upon the end of a trail, but at every step the continuation of the trail must be pointed out

to him. With the guidance of the instructor he may get to the end of it, but he will never travel a trail alone. This is why the great majority of Ph.D.'s from universities are still-born, never publishing anything after the thesis.

The investigator, on the other hand, has a distinct power of initiative. The instructor's business is to put him on the end of a trail and then to leave him alone. He asks advice, but he uncovers his own problems and does not need to have them pointed out.

The fact is that relatively few people are really investigators; and many of these are not real teachers. If this discussion is to exclude those who cannot teach, and also those who can teach but cannot investigate, its range of application is not very extensive as compared with the number of teachers, but there is still left a very respectable minority.

But is not such restriction necessary? Would any one claim that investigation will reclaim one who cannot teach? Or that a good teacher should waste his time on investigation when his mental structure forbids it? Just as well try to compel some one to be an artist when there is no such ability in him.

3. *Teachers who can do research work.*—These are real teachers who also have the investigative ability and to these only can the question apply. Are such teachers made better teachers by their investigations? If so, the practical outcome should be that this combination should be first sought for in selecting a teacher of biology for a secondary school; if no such combination is available, then good teachers should be looked for; and when this source is exhausted, the department had better be abolished temporarily. Upon this basis, the selection of teachers of biology for secondary schools would be more restricted than it is for universities, for in the latter case good teaching is not always considered. I may say, in passing, that samples of the poorest teaching in the world are not found in secondary schools, but in universities.

But what foundation is there for the claim that a good teacher in the secondary schools is made a better one by being also an investigator? As was said in the outset, I can only show what investigation does for a good teacher in the university, leaving

you to judge whether these results would also be beneficial in the secondary school. Instead of seeking to develop a long list of the advantages of investigation to a good teacher, I wish to call attention to only three that are perfectly definite and of fundamental importance. They have been obtained from the experience of many teachers, who were very successful as teachers before they became investigators, and who have experienced the transforming effect on their teaching, making it far more satisfactory to themselves and to their students in every quality that enters into good teaching. Those whose experience I draw upon are first and foremost teachers, and for our purpose are better illustrations than those who are first and foremost investigators. The first of the three results to be mentioned is that:

(1) *Investigation increases accuracy.*—The knowledge of biology that comes from second-hand information is either too vague or too definite; it never quite grasps the real situation. Such a teacher is either never quite sure of the facts or he is too sure. The former condition makes him uncertain and indefinite about things that are settled; the latter makes him certain and definite about things that are not settled. He is a dependent, leaning generally upon some one author. I have always thought of him as a pump, filled from some reservoir, and in turn filling the little pitchers held under his nose; rather than a perennial spring, as every true teacher should be. The accuracy, the grip, to which I refer is not to be confused with grip on the contents of some book, but grip on the contents of the subject; a grip that never comes to the biologist from any amount of second-hand information.

The accuracy to which I refer has to do not only with the facts of biology, but also with their presentation. The really good teacher instinctively makes his facts glow in presenting them. This glow comes from allowing the imagination to play over the facts until lumps of coal look like diamonds. This is fine so long as it is safe, in fact it is the highest expression of teaching ability. But there is lurking here a serious danger; for the greater such ability, the greater the temptation to carry the facts

far beyond their significance, or even entirely outside their relations. In such cases, the temptation is to be sriking rather than to be true. I remember now with shame and confusion my own earlier teaching. Wild connections were suggested, fanciful explanations were given, and a general amateurish attitude of mind was displayed. And one is conscious of it all the time, for when a master of the subject visits his work such a teacher hedges at every turn. Compelled to stick to the facts he is sure of or thinks he is sure of, he discovers that his chief stock in trade is something he is not willing to disclose to a competent critic. This sounds severe, but you will not think so when you know that it is a personal confession, not only of my own but also of scores who have confessed and repented, and I trust have been forgiven.

No such tendency can coexist with investigation, which either roots it out or uncovers the fact that the man is not an investigator. Nor have I ever discovered the fact that clipping the wings of the teacher of flamboyant or demagogical tendencies makes him any the less effective as a teacher. The most inspiring teachers are in the greatest danger, and most need the steadying influence of a first hand grasp of the facts. You will find that facts properly related and properly presented, with the glow of enthusiasm that belongs to the investigator as well as the glow of imagination that belongs to the teacher are just as attractive and inspiring as any glittering tissue of inaccuracies.

I have spoken of accuracy as to facts, and accuracy in their presentation; but still more fundamental is some definite experience as to what accuracy involves. In a well-prepared text all the facts are beautifully clear and definite, and they seem as clear as meeting people in the street. But try to establish some facts yourself, and you will understand what it means; and you will appreciate how the clean cut statements of the text either become dim with uncertainty or show that their establishment has involved an extraordinary amount of patience and insight. No man ever goes through that experience and continues to teach loosely. Facts are too dearly gained to be trifled with, and cheap imitations are abhorrent to those who have dug facts out of the mine.

There are some pertinent questions suggested here. May not the cultivation of accuracy become deadly, and make teaching a grind to the pupil rather than an inspiration? My answer is that at this point the ability of the good teacher expresses itself. It is his art to present facts attractively and effectively, and he can do this as well with real, sharp cut facts as with those that are either imaginary or hazy in outline. The deadly presentation of facts is the function of the investigator who cannot teach, and we have ruled him out of the secondary school and restricted him to the university.

Again, may not the investigating teacher attempt to present things beyond the grasp of his elementary pupils? The pure investigator will be sure to do this; but the investigator who is a teacher never will. As I understand it, one of the fundamentals of teaching is to relate material to the capacity of the pupil. But who is able to test the capacity of the pupil except he who is able to lead him beyond his depth? I have discovered that things judged too hard for the pupil are chiefly those that are unfamiliar to the teacher. An alga is easier to understand and hence easier to teach than a buttercup, and yet most teachers regard the alga as too difficult and turn to the buttercup. "Too difficult" for the pupil is usually a phrase to cover unfamiliarity on the part of the teacher. It is only the teacher who knows these so-called "difficult" things who can really gauge the capacity of his pupil.

Again, is the investigating teacher in danger of narrowing his course to the region of his own special interest, and of neglecting the general presentation of his subject? Again I would reply that no real teacher is ever in such danger; this danger belongs to the pure investigator, as many courses of study offered in universities will prove. My experience with teachers of botany has been exactly the contrary. Those who have had some training as investigators and have secured such a grasp of the subject as they must have in order to be investigators, have been the only ones who have given a general view of the plant kingdom. The others, who are not investigators, have generally contented themselves with a very inadequate presentation of flowering plants. The investigator today must have a large background;

and if he is also a teacher his courses will be broader and more general than those who have never obtained such a general grasp.

2. *Investigation insures independence.*—This means a change of mental attitude, from the habit of dependence to that of independence. Only during the progress of an investigation does one realize fully what it means to "work up" a subject and reach a fair estimate of its status at any given time. The usual teacher is dependent upon one or at most a few books. Some text has been adopted, and I venture the assertion that in most cases the whole conception of the teacher is to master and illustrate that text. To him the subject means a book more than anything else. The investigator is at once removed from the book and plunged into the bibliography. He learns the evolution of the subject, the diversities of opinion and the facts upon which they are based; and develops an independent judgment, which is further strengthened by his own experience in discovering and estimating facts. You may not appreciate it, but the bibliographical habit is harder to cultivate than the investigative habit; for it does not merely mean running down all references to a subject; any good librarian can do that; but it really means the ability to weigh the mass of testimony thus uncovered and to apply it as needed. I have never seen this judicial habit cultivated apart from investigation. In this case it is the subject and not any book that is taught; the adopted text taking its proper place as a convenient supplement to the teacher's work, and not as an unquestioned authority.

The chief independence, however, comes in the handling of illustrative material. We need here the investigating, independent spirit more than anywhere else in our schemes for teaching biology. Most of the suggestions as to the use of material have come directly or indirectly from teachers with only a university experience. The suggestions are the best possible under the circumstances, but the circumstances are not ideal. Any good teacher can take these suggestions and make a practical application of them and criticise the result; but if the criticism is adverse, the university man is asked to "guess again." It is like fitting a shoe by means of a "go-between," and is an indefinite and

somewhat vague process. What is necessary is to bring the shoe-man and the foot together, and then there will be a definite result. What we need to find among the teachers of biology in our secondary schools is not so many "go-betweens" between the university and the school; but more teachers independent enough and able to investigate for themselves the problem of appropriate material and its handling. This would be a real investigation, and would need all the qualities of an investigator to reach any valuable and abiding results. Without this the conclusions would be largely empirical, and would not be justified by wider experience. The number of factors that enter into any experiment is only appreciated by those who have been trained to disentangle them. This means that the investigator who is also a teacher of biology in the secondary schools is in a position to develop the department for which he stands.

3. *Investigation insures that the teacher will keep close in touch with the advance of his subject.*—It is a notorious fact that a text-book in biology, even with a rapid succession of new editions, is far behind the subject. Any such book is out of date as soon as it has assumed the rigidity of publication. If it is good, it presents a fair outline of the subject at the date of writing, not necessarily at the dates of successive "editions," which too often change the date on the title page without any corresponding change of the contents. If this "keeping current" involved only familiarity with the new facts that might pertain to an elementary text in the way of additions or corrections, it would not be so serious; for there are enough old and well-established facts to keep the pupil in the secondary school busy; but the serious feature of the situation arises from the rapidly changing points of view developed by these new facts, which results in extensive reorganization of methods of presentation. For example, our conceptions of the plant kingdom have been shifting so much of late that there is not in existence a single text-book used in the secondary schools that is not years behind; some of them as much as 50 years behind. Even the most recent have today an antiquated flavor.

This sort of presentation is not permissible in universities;

and it is for you to judge whether it is any more permissible in secondary schools. If not, how is it to be remedied? I know of no one except the investigator who has developed such professional interest in his subject that it compels him to keep current, and at the same time has formed such connections that he is able to keep current.

My summary of the situation, therefore, is this: An investigator is trained in accuracy, is entirely independent, and is compelled and able to keep abreast of his subject. These qualities are essential in the university instructor. Do you consider them to be equally essential in a teacher in the secondary schools? All the dangers suggested as arising from the cultivation of these qualities do not arise because of the investigation, but because the investigator is not a good teacher.

ABSTRACT OF PAPER BY DR. MAXWELL, MC KINLEY HIGH SCHOOL, CHICAGO, DISCUSSING PROF. COULTER'S PAPER.

It will be granted without discussion, that a science teacher is better prepared for his work by having done original investigation. If he is the best type of science teacher he must have the investigator's spirit well developed, but more than that he must be able to impart that spirit to others.

We find in our secondary schools today many men who have in their college and university days spent much time in original investigation, and who come to their work with the intention of continuing research studies. But the multiplicity of duties in the high school will not permit of time to do more than keep the laboratory courses going. The search for and preparation of material, the preparation of outlines, the oversight of the pupils' work, and the necessary examination of papers more than fills the time which should be allotted to school work. He will be very fortunate if time is left for scientific reading to keep in touch with the progress of the day, and for such social and home duties as he should take time to attend.

The college professor with his assistant to attend to the details of work, should have much time for research. The high school man has but little time that he can afford to put in such work, unless he neglects teaching work, or overtaxes his strength.

But may not the true teacher's efforts to constantly revise methods and devise apparatus for presenting his subject in the best manner, be accepted as original work? Again, is he not doing original work if he gets the investigator's spirit into his pupils? There is a place for the investigator who can not teach; there is a place for the teacher who can find time to keep up lines of original work, but there is also a place for the true teacher who finds but time to do his teaching work well, and who must be content to let his influence on the lives of his pupils represent his original work.

WHAT IS MULTIPLICATION?

By A. Latham Baker,
Manual Training High School, Brooklyn, N. Y.

Attention has been called to this question by the recent appearance of Judd's "Genetic Psychology for Teachers," in which is reproduced the old misapprehension that multiplication is a special phase of addition. The prominence of the writer and the unusual merit of the book compel attention to an error that otherwise might be passed over in silence as another instance of the conservatism of pedagogy, and of the more than feline multiplicity of lives possessed by this ancient inaccuracy. Its reappearance in such authoritative form is unfortunate for those who still adhere to the ancient error, who are thus strengthened in their "orthodoxy."

He says, "When we come to multiplication and division we have modifications of the process of grouping (addition and subtraction) * * * Division is therefore a special case of subtraction. Division and multiplication thus come to be processes dealing with units of higher order" (produced by addition and subtraction).

These quotations show that the writer has confused the simple and universally applicable operation of addition with the far more complicated and in its applicability, limited operation of multiplication.

It is curiously surprising that the acumen so conspicuous

throughout the book did not discover that the definition breaks down the moment it is applied to fractions. Particularly noticeable is the failure when applied to stroke and vector multiplication, where no amount of addition of the original elements will produce the product.

Likewise in his definition of division he has confused the abstract operation of division with the concrete semi-mechanical operation of finding the quotient. To define division as a special case of subtraction because in the mechanico-mental operation of getting the result we do perform subtraction is no more reasonable than to define division as a special phase of crank-turning because we can arrive at the result by turning a crank of a calculating machine. It should be carefully distinguished that division is a mental operation the result of which is arrived at, except in the case of simple and familiar quantities, by a series of partial divisions and subtractions, each part of the quotient being subtracted as soon as obtained. But these subtractions are not division, nor have they properly anything to do with with the division, being merely operations to clear away the *débris* for a new partial division. They have nothing to do with the division *per se,* being merely a house cleaning process to prepare the way for a new partial division.

Addition is merely accumulative combination of elements, and is applicable not only to mathematical concepts but to concrete objects, fingers, pebbles, etc., and to this extent is not a purely mathematical operation; it is concrete as well as abstract, in that it can be applied to concrete objects.

Subtraction is the decumulative combination of elements, and is likewise applicable to concrete objects, within the limits of correctness. When applied to abstract concepts, debt, direction, etc., its continued application results in a new number concept, the negative number.

These two operations are operations which do not change the original elements but merely adjoin them unchanged into a cumulative or decumulative result. So long as the elements are unchanged these are the only possible operations.

To arrive at an idea of multiplication we must ascertain the

permissible operations performable upon number. To do this we must find out the properties of number. Primary number has only one property, its differentness from unity. This property can be used as a directory mandate for the possible operations. If we use the evolutory differentness from unity the differentness which produces the number from unity, as the mandate, we get multiplication, the doing to the operand (multiplicand), what was done to unity to produce the operator (multiplier). If we use the involutory differentness, the differentness which converts the number into unity, we get division, the doing to the operand (dividend) what was done to the operator (divisor) to convert it into unity.

These are transformational operations; operations which transform the operand into an entirely new and different number. They are purely algebraic, being limited, unlike addition and subtraction, to operations upon discrete number.

A not entirely satisfactory illustration of the difference between the two operations of addition and multiplication is the putting of two canes together for addition; for multiplication we would be compelled, because the first was triangular, black, smooth and uniform in size, to transform the second cane, which was round, white, knotted, tapering and with a knob on the end, into a triangular, black, smooth, prismatic stick. It is transformed into an entirely new and distinct form, and its original features have disappeared.

So in numbers, addition and subtraction are merely adjunction without change of the original elements. Multiplication and division are distinctive transformations, the destruction of one element and the production of an entirely new and different one, like the growth of a plant from the seed.

From the primary number of these are all the operations permissible until we produce by subtraction the new concept, negative number, introducing reversion; and by division (evolution) the additional concept, irrational and complex numbers, introducing mean reversion.

These definitions of the operations are general, holding for all branches of discrete mathematics, algebra, complex functions, quarternions.

Involution is merely that special case of multiplication in which the first operand and all the operators are the same, working from unity to the result.

Evolution is the special case of division in which all the operators and the last operand are the same, working from the operand toward unity.

Incidentally, as a corollary to this, comes up the similarly faulty definition of exponent, so persistent in the school room, the number which shows how many times the base is taken as a factor. This is absurd of course when the exponent is a fraction, and is apologized for by asking for an extension of the idea to cover fractions. Why not start right at the beginning and define exponent as the number which indicates how many multiplicative and divisive operations are to be performed upon the base? Whether in the case of fractional exponents we should speak of power or not, about which many make so much ado, is merely a question of definition; whether we define power as the result of equal integral multiplicative operations or of equal operations, multiplicative or divisive. The question is largely one of convenience and convention, narrowness or breadth, and not one of right or wrong.

DECREASE IN THE NUMBER OF PUPILS OF CHEMISTRY IN HIGH SCHOOLS, ITS CAUSE AND REMEDY.

BY JAMES E. ARMSTRONG,

Principal Englewood High School, Chicago.

The statistics of the National Commission show a decrease of 2% in the number of pupils in secondary schools studying chemistry in the last five years, but there is some comfort for the teacher of chemistry in the fact that the number studying physics has fallen off 4% during the same time. The cause of this is not far to seek. In the same report it will be seen that during the same time many new studies have grown in popularity, studies that were no part of the high school course but a few years ago.

Among these are biology, civics, history, physical geography and even English. Ten years ago papers were being read at teachers' meetings urging that English should be more generally taught and now it is the most generally compulsory study. The reports show very rapid increase of all these new studies. For a decade before this, chemistry and physics were the new studies and they had a marvelous growth. Greek belonging to the old curriculum lost its footing completely under the avalanche of new studies. Latin and algebra trembled for a time, but now are holding their own remarkably well.

Another cause for the decline in number of pupils studying both these sciences is the fact that at first they were taught in the earlier years of the course and were more than correspondingly easier. Instead of physics we had natural philosophy. It was not a laboratory science, but a text-book-demonstration-and-observation science. It was not a very exact or exacting study, but the boys and girls got a whole lot of information out of it. I question whether we have not lost something in the evolution up to physics as splendid as that science is to-day. Chemistry was a mixture of pyrotechnics and pharmacy, cooking and dish-washing. Its evolution is no less marked, though I think there is less to be lamented in the change. These changes to more exact sciences as well as some other influences have moved them farther along in the course till they now are found almost always in third and fourth years of the course. In Chicago, there were so many objections to the new study of biology on account of the dissections required at first of beginning pupils that physical geography was introduced, not so much for the study itself as to get a science that was less objectionable. Biology was therefore transferred to second year, physics to third and chemistry to fourth. This brought chemistry in conflict with geology and astronomy to the detriment of all three.

The college requirements have also come in for a share in the decline. High schools have usually responded freely to their call and many college men knowing better what they require for their own relief than what the common people need have led us into unfruitful study. I recently attended a conference of college and

high school men, where the topic for discussion was "Some Recently Adopted Text-Books of Chemistry." The paper was by a college man. His first criticism upon the first book considered was that it contained but three experiments in quantitative analysis and they came near the latter end of the book. If chemistry is to be a profitable study in the high school course, there will not be much room for quantitative analysis in it.

Another cause for decline is the expensive outlay for laboratories and apparatus. I have seen laboratories fitted up with the most modern appliances and all the conveniences that a well trained teacher from a college laboratory could imagine, but it stands idle most of the time. There are but few pupils that choose chemistry out of the many electives and the fixtures make it impossible to use the room for any other purpose. The laboratory table exhibited at this last meeting of the association would go a long way toward reducing the expense by making the room available for some other purposes. I have one other suggestion, although it may seem like a heresy at a meeting where there are teachers of physics. I would have chemistry precede physics in the curriculum. Physics requires more mathematical training and careful manipulation. Chemistry is more of an observation science and the experiments require less exacting care. If we could have a little of the old natural philosophy in the first year instead of the so-called "temperance physiology" I think all would be willing to reverse the order of physics and chemistry. Physics, which is required by all colleges and our normal school, then coming in the fourth year would lose nothing by the transfer and chemistry would take its proper place nearer to the larger groups of pupils.

AN EXPERIMENT ON FRICTION.

ALBERT B. PORTER,

Chicago.

The following simple illustration of the laws of friction never fails to arouse interest and curiosity when first seen. Place a meter stick horizontally upon the extended index fingers as shown

in the sketch. Now slowly move the hands toward each other. It will be found that slipping takes place first upon one finger and then upon the other, but in such a manner that when the hands come in contact the middle of the meter stick rests upon the fingers so that the stick balances. Now place a weight of say 100 grams upon the stick near one end and repeat the experiment. As before, it will be found that when the hands come into contact the fingers lie under the center of gravity of the system, which will now be some distance from the center of the stick.

The explanation is so simple that it may well be left as an exercise for the students with, possibly, the suggestion that friction depends upon pressure, and that the friction between two surfaces at rest is greater than when there is relative motion.

MATTERS ON PHYSIOLOGY AND HYGIENE.

The following recommendations were adopted at a general session of the Central Association of Science and Mathematics Teachers Nov. 25, 1904, after the report of the committee had been presented:

In view of the facts set forth in this report, we make the following recommendations to the Central Association of Science and Mathematics Teachers now convened:

First:—that a committee of five be appointed by the President of this Asso. whose work shall be to bring this question before teachers' gatherings in the states and localities here represented, for discussion and action, during the coming year so far as possible.

Second:—that this Asso., believing that the laws regarding this question as now existing in the states of Illinois, Michigan, Iowa and Minnesota are extreme and detrimental to the best interests of temperance, hereby pledges itself to use its influence in these states, to secure a modification of these laws, so that they shall conform to the so-called Meyer bill as recommended in Massachusetts, or to the laws now existing in Wisconsin and Ohio.

(Signed) J. E. Armstrong,
H. N. Goddard.

(The other members of the committee were not present when this report was ready for signing, but had agreed by letter to the general plan.

E. J. Armstrong, Chairman.)

The W. C. T. U., upon learning of the attitude of the Central Association of Science and Mathematics Teachers, toward the so-called Temperance teaching as set forth at the meeting a year ago, have requested the publication of the following:

AN OPEN LETTER.

In the January, 1904, number of "School Science" in the "Report of the Meeting of the Central Association of Science and Mathematics Teachers," we read with surprise the following resolution:

"Whereas, The states represented in the Central Association of Science and Mathematics Teachers all have laws requiring the teaching of physiology and hygiene with special reference to the nature of alcoholic drinks and other narcotics, and

"Whereas, We believe that the method of presentation required by these laws makes such teaching detrimental to the best interests of both education and temperance, and

"Whereas, We heartily favor every wise effort to do away with the evils which result from the use of alcoholic liquors and narcotics and desire to co-operate with the agencies that are working to eradicate these evils, therefore, be it

"*Resolved,* That a commission of five be appointed by the chair to investigate this whole matter, to make a definite report, and to present recommendations at the next annual meeting of this association."

(Signed) J. E. Armstrong,
H. N. Goddard,
H. L. Roberts.

The point of complaint in these resolutions is not against the matter these laws require taught but against "the method of presentation" which they say the laws require.

We, the undersigned, residents in the states represented by the Central

Association of Science and Mathematics Teachers, namely, Ohio, Indiana, Illinois, Michigan, and Wisconsin, Presidents and Superintendents of Scientific Temperance Instruction of the State Woman's Christian Temperance Unions in those Commonwealths, the organizations which have been instrumental in securing the passage of the laws referred to, would remind the "Central Association of Science and Mathematics Teachers" that there is no ground whatever for the complaint that "the method of presentation required by these laws makes such teaching detrimental to the best interests of education and temperance," for not one of the laws in the states in question specifies what the method of presentation of the subject shall be, unless they refer to the requirement of the Illinois law that instruction on this subject shall be "oral.... in the lowest three primary school years" where pupils are unable to read.

But it can not be possible that intelligent teachers of science would designate the oral method of instruction for such primary children in simple laws of health including those that relate to alcoholic drinks, cigarettes, etc., as "detrimental to the best interests of both education and temperance."

The schools furnish three sources of information to the child, first, the teacher; second, the book; third, observation and experiment. Lacking in any of these, the means for securing the best results in education on any subject are incomplete. The law in specifying that text-books shall be provided for pupils' use in this as in other subjects, is providing only that the pupils shall have the book as one source of information. The Century Dictionary defines *method* as "a way of teaching or proceeding." The fact that pupils have books on the subject taught does not prescribe to the teacher the method of presenting the truths the books teach any more than the pupil having a book in arithmetic prescribes the method of teaching that subject.

If the critics had only studied more carefully the laws they criticise, they would have seen:

First, That the Illinois and Ohio laws, instead of "requiring a method of presentation," both definitely specify that

"In all normal schools, teachers' training classes, and teachers' institutes adequate time and attention shall be given to instruction in the best methods of teaching this branch." Thus "the method" is not only left to the educational authorities, but such authorities are made directly responsible for devising the best methods.

Second, The law of Indiana leaves the question of "Methods" of teaching to the boards of education, educational institutions, and local school officials, instructing them to adopt such methods as shall adapt the same (instruction) to the capacities of the pupils in the various grades.

Third, The Wisconsin and Michigan laws say nothing about "methods of presentation" of the subject, thus leaving the whole question of methods to the teacher and educational authorities of those states.

Assuming that the Central Association of Science and Mathematics Teachers will be glad to know that they are mistaken in thinking they have a cause for complaint against our temperance education laws, we, representatives of the mothers of the children they are teaching, urge these teachers to now devote conscientious effort to the question of how they can best meet the obligations laid upon them by the states of Ohio, Indiana, Illinois, Wisconsin and Michigan to teach these children the physiological reasons for obeying the laws of health including those that teach abstinence from alcoholic drinks and other narcotics. By thus exchanging the role of destructive criticism for that of constructive effort, the cause of health, sobriety, morality will be advanced in coming generations.

Englewood High School, Chicago, April 6, 1904.

Mrs. A. S. Benjamin, Dear Madam: Your letter and those of others interested in the Temperance cause, together with the Open Letter, have been referred to me. Personally I have no objection to publishing the letter but before doing so I wish to say that I believe the letter would do great harm in arousing a state of antagonism that should not exist between the temperance workers and the teachers in the public schools. It is not at all surprising that you should all be alarmed at any attempt to undo the work you have carried through so successfully, but I fear you have misunderstood the attitude of our association. Many of the personal letters show a bitterness of feeling that indicate the writers have no faith in our sincerity and even hint at collusion. We are accused of hasty judgment as well as of being lacking in sound reasoning ability.

The "Open Letter" assumes that "Method of presentation required by these laws," refers to the way of teaching, and the dictionary is quoted to show that we do not know what method means. Surely these ladies do not wish us to understand that "method" refers only to teaching. It seems that the second resolution had no effect on those who hint at collusion.

Now, I wish to say briefly, that we object to the fact that the subject must be presented in the first year of high school in ten weeks, after the pupil has become nauseated by repetitions of it in all the grades. In all high schools, subjects run by years or half years. If Boards of Education were in sympathy with the temperance teaching, they would doubtless give it at least a half year; but the rule is they give it only the minimum time prescribed by law. We see, by several years trial, that so little real scientific knowledge can be gained in ten weeks that we feel that it is a waste of time, especially as the subject has lost its freshness by the repetition lower down. If we could give a half year to it, we could really teach the subject as it should be taught and especially if it came in second or third year. Pupils in first year have no adequate knowledge of Physics, Chemistry or Anatomy. All of these are necessary to a scientific study of Temperance Physiology. I know that these ladies will look with alarm upon its transfer to a later year in the high school course, but they should remember that these children have had the subject many years in the grades through which they have passed. It has therefore done all the good it can unless it can be presented from a new standpoint, and during their first years in high school, they are not prepared for a new standpoint. It is therefore, very irksome. Teachers feel this and dislike to teach it. If some knowledge of other sciences could come first, it would become fresh and full of interest, especially if half a year could be devoted to it. They have all had the subject when they come to us. Why

not let them wait until their third year for this new view? The only reason seems to be that so many will leave school before reaching third year. Certainly, but they have had all they can absorb in the elementary schools until they have had some other science to give this enlarged view. Why spoil the work of one half the pupils by repeating the work in first year?

We have little objection to the law as enacted in such states as Ohio but great objection to the law of Illinois. Here the whole matter is made a matter of pages, words, hours, etc. All the initiative of the teacher is removed and dry husks remain. Can we not co-operate together to improve this state of affairs? We have no desire to promote intemperance nor unscientific, unpedagogical teaching. Let us try to find the best thing that can be done for the children. We believe you are conscientious in your work and mean to do the best for the cause. We are instructing the children and wish to do better by them than we can do under the existing circumstances. We believe the laws are at fault in some, if not in all the states, and hope they may be improved.

Now before we do anything more, we wish to know if in the light of this information, you still feel that you would like to have us publish your open letter.

Yours truly,

J. E. Armstrong,
Chairman of Committee.

The above letter was sent to Wm. A. S. Benjamin for presentation to the representatives of the W. C. T. U., and reply received stating that they still wished to have the "Open Letter" printed.

REQUEST.

It is hoped that our friends and readers will try to increase the circulation of School Science and Mathematics among their friends and acquaintances. Sample copies will gladly be mailed to addresses furnished.

Back numbers of School Science, School Mathematics, and School Science and Mathematics may be had for 25 cents a single copy. The Mathematical Supplements for 15 cents a copy.

Vol. I., No. 2, April, 1901, of School Science is out of print. For all copies returned in good condition 25 cents will be paid.

In sets the prices are, postpaid:

School Science, Vol. I.	$1.75
" " Vol. II.	2.00
" " Vol. III.	2.00
" " Vol. IV. (3 numbers)	75

School Mathematics and Supplement, Vol. I. (5 numbers), $1.00.

Notes.

Teachers are requested to send in for publication items in regard to their work, how they have modified this and how they have found a better way of doing that. Such notes cannot but be of interest and value.

DEPARTMENT OF METROLOGY, NOTES.

National Bureau of Standards. The last Annual Report of the Secretary of Treasury, Leslie M. Shaw, contains the following:

"Pending completion of its two new buildings, the work of this Bureau has been carried on in temporary quarters in the Coast Survey and Butler buildings, and at 235 New Jersey avenue SE. The new mechanical laboratory will be occupied in a few months, and the construction of the physical laboratory, begun in March, is well under way.

Preliminary work necessary in the most important lines of testing is well advanced. The demands made upon the Bureau, however, have been far in excess of its ability to meet. Requests have been made by Government bureaus, manufacturers, and scientists for information regarding standards, methods of construction and measurement, and physical constants, as well as for the comparison of their standards with those adopted by the Government. The verification of standard bars and gauges for use in manufacturing fine machinery was begun during the year. A bench standard for testing surveyors' and engineers' steel tapes was designed for the State of Massachusetts, for the city of Chicago, and for manufacturers of steel tapes. A set of model weights for State and city inspectors is being designed. The State laws concerning weights and measures have been compiled for early publication.

"The testing of clinical thermometers was begun during the year. Manufacturers submitted standard thermometers for verification, and the corrections furnished, after careful study, resulted in a marked improvement in the accuracy of the readings of the clinical thermometers manufactured. Manufacturers have cheerfully co-operated with the Bureau in this matter. The Bureau is now prepared to test thermocouples up to 1500° C. (2700° F.), and the important work of testing pyrometers will soon be begun.

"Plans for the construction of primary mercurial resistance standards and of standard cells have been developed and materials procured for their construction. Facilities are now provided for testing electrical measuring instruments as well as resistance standards, inductances, capacities, and condensers.

"A photometric laboratory has been equipped for the testing of standards of illumination, and a comparison of the standards used by manufacturers of incandescent electric lamps has been undertaken."

R. P. W.

Confusion of Measures in India. A. E. Potter, Inspector of Schools, Burma, in a brochure favoring the adoption of the metric system in India (Decimal Association, 1904), says: "The Kos [measure of distance] varies in almost every province in India. In Agra and Muttra it is about 1¾ miles, on the hills about one mile, and all local Koses differ from the imperial Kos, which is about 2¼ miles. The Biga [land measure] varies in almost every village. The Factory Maund [large weight] of Calcutta differs from the Bazaar Maund, and both differ from the Madras Maund. The Viss [small weight] of Burma again differs from the Viss of Madras. The Hath [cloth and linear measure] varies in every district, and we find even two government standard Haths. In Burma almost every district has its own Basket. Take a simple type of business transaction: Salt is imported into this country at so much a ton, duty is paid at so much a maund, and it is then sold at so much a viss." R. P. W.

Metric Teaching in England. The English Education Code, adopted in 1895, has the following: "The scholars in Standards V, VI and VII should know the principles of the metric system and be able to explain the advantages to be gained from uniformity in the method of forming multiples and sub-multiples of the unit." A competent authority writes that on the whole "the metric system is generally taught fairly in all public schools both higher grade and elementary. Nearly all the School Boards of the country helped us to bring the question forward and were active supporters." R. P. W.

Weights and Measures of old Carthage. A Paris correspondent of the Scientific American Supplement in describing the archiological excavations at Carthage says: "The Carthagenian system of weights and measures can be reconstructed from the objects found in the tombs. Many different forms of weights were brought up. One set contained the two plates of a balance and nine lead weights of truncated pyramid form, varying from 188.6 to 9.12 grammes. Another set were of a greenish lithographic stone, and well polished, while another set were of bronze, filled with lead in the center." R. P. W.

Standard Time. Twenty-one years ago last November standard time was inaugurated throughout the United States, taking the place of local time. Mr. W. F. Allen, then and now Secretary of the American Railway Association, who projected and carried through the system to a successful issue, has prepared a *Short History of Standard Time and its Adoption in North America.* "By this change, at the stroke of the clock at high noon on November 18, 1883, fifty different standards of time resolved themselves simultaneously into four, while the minute hands of watches and clocks were reset at all points to the same minute mark on the dial. Only a few roads delayed action, and these conformed a few weeks later. And so on the date named a most singular change in the daily habits of the people of this country and of Canada was quietly accomplished."

Mr. Allen further says: "In every country in Europe except France and Russia, railway and local clocks are regulated by the time of either the Greenwich meridian or by that of meridians differing exactly one hour or two hours therefrom. South Africa, Australia, Japan, the Philippine Islands and Porto Rico also base their time reckoning upon meridians differing by even hours from that of Greenwich. In Russia the time varies from the even hour by about one minute only. In nearly all parts of the civilized world, therefore, the clocks and watches, if precisely regulated, beat seconds exactly together, their minute hands point to the same part of the dial—only the hours differ according to the governing meridian."

"The people of the present generation can hardly appreciate the difficulties which these numerous standards presented to the traveler, and from which they have been happily delivered."

Thus a single master hand working through the proper channel wrought one of the most remarkable reforms of modern times, of world wide extent, and lasting as time itself. Yet in point of value such a change is insignificant in comparison to the universal adoption and use of the metric system of weights and measures. R. P. W.

Report of Meetings.

REPORT OF THE BIOLOGY SECTION OF THE CENTRAL ASSOCIATION OF SCIENCES AND MATHEMATICS TEACHERS.

The meeting was called to order at 2:00 P. M. Friday, Nov. 25, 1904, by the chairman, Dr. Otis W. Caldwell of Charleston, Ill.

The opening address was by Prof. John M. Coulter, of the University of Chicago, subject: "The Relation of the Teacher's Research Work to His Teaching in Secondary Schools."*

This was followed by a formal discussion by Fred L. Sims of La Porte, Indiana, High School, and Fred B. Maxwell, of McKinley High School, Chicago. An open discussion followed. Mr. Sims' discussion led Dr. Coulter to ask whether it is likely that there would be a residuum of good teachers who would not allow their interest in the subjects pursued in research to lead them into over-emphasizing the corresponding portions of the high school course.

In response Mr. Sims gave instances of two teachers who had erred gravely in this respect, but was able to name three whose work had been greatly improved by some experience in research work.

Mr. Mitchell of Hyde Park High School regretted the conditions which leave the average teacher but little opportunity for carrying on research work except during a vacation.

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* This article is published on another page.

Mr. Caldwell told of a very busy teacher who finds time for it during the late hours of the afternoon, because he finds it the only means by which the proper attitude toward his subject can be kept.

Only by keeping at some problem in research, Mr. Caldwell maintained, can a teacher preserve the truly scientific spirit. Such work need not necessarily lead to publication, perhaps would better not, but some searching for truth should constantly be made.

Professor S. A. Forbes of the University of Illinois presented the second paper, on the subject: "The Economic and Industrial Phases of Secondary School Biology."*

The paper was formally discussed by Miss Rousseau McClellan of Shortridge High School, Indiana, and Thomas Large of the Oak Park (Ill.) High School.

In the open discussion, Mr. Maxwell expressed the opinion that while the economic feature should not be made the basis of the course, more of the economic can be introduced into the course than has been in the past.

Mr. Smith of Chicago Normal School maintained that we should make our subjects touch our pupils' lives as closely as possible and that we can be aided in this respect by adding the economic feature to our present courses.

Mr. Holtzman of Robert Waller High School, Chicago, advocated introducing into the courses more studies of living animals and their economic significance, letting this work replace, if necessary, some of the anatomy of the dead specimens.

The query was raised as to whether the present filling of positions with university-trained teachers is not resulting in giving us teachers whose main purpose is to prove evolution and who neglect the life-sides of the subject.

Mr. Mitchell stated that in his experience economic studies had been invaluable in creating interest and had led naturally to ecological and morphological studies.

The meeting then adjourned to meet again on Saturday.

When the meeting was resumed Saturday morning the following officers were elected for the ensuing year:

Chairman, A. H. Conrad, Chicago.

Vice-chairman, Fred L. Charles, De Kalb, Ill.

Secretary, Miss Minna C. Denton, Milwaukee, Wis.

The question was raised as to what should be the character of the Saturday morning meetings of the section. The sentiment of the meeting was that the Saturday morning program should be fully as strong as that of the Friday afternoon meeting, in order that it might be worth the effort required for out-of-town teachers to attend.

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* This paper will appear in a following number of this Journal.

The Report of Committee appointed at last year's meeting on "The Course in Biology for Secondary Schools," was presented by Dr. Childs, of the Univ. of Chicago.*

At the invitation of the chairman, Dr. Childs discussed certain features of the report, placing special emphasis upon the value of field-work, and the possibilities for such work offered by a comparatively small plat of ground near or on the school-grounds in which natural conditions of native flora can be imitated. Such a plat affords material for zoological field-work as well as botanical.

Mr. Maxwell moved that a discussion of this report be made one of the principal subjects of next fall's program, and that Dr. Childs be asked to lead the discussion at that time. The motion was carried.

The report presented by Dr. Childs was then adopted as read.

Mr. Mitchell moved that the committee suggested in the report for outlining suitable high school courses in botany and zoology, be divided into two groups, one for botany and one for zoology, which should form a unit for biology.

The committee appointed by the chairman was as follows:

Chairman, W. W. Whitney, Chicago, Ill.; Mr. Smith, Chicago, Ill.; Miss Elma Chandler, Elgin, Ill.; Miss Rousseau McClellan, Indianapolis, Ind.; Mr. W. R. Mitchell, Chicago, Ill.; Miss McMinn, Milwaukee, Wis.; Mr. T. L. Hankinson, Charleston, Ill.; Mr. F. B. Maxwell, Chicago, Ill.

The meeting then adjourned. ELMA CHANDLER, Sec'y.

REPORT OF PHYSICS SECTION.

(From January number.)

Saturday, November 26, 10:00 A. M., Assembly Hall, on the second floor, Chairman Tower presiding. The Committee on Nominations presented the following names:

For Chairman: A. A. Upham, Whitewater Normal School, Wis.

For Vice-President: E. A. Strong, State Normal College, Ypsilanti, Mich.

For Secretary: F. R. Nichols, R. T. Crane M. T. H. S., Chicago.

On motion the Secretary cast the ballot of the section for the above officers.

After a short discussion of the question, What are the best aims and results in laboratory work in Physics? the section adjourned to a joint meeting with Mathematics Section, where the following program was carried out:

Address: "The Introduction of Meteorology into the Course of Instruction in Mathematics and Physics." Professor Cleveland Abbe, U. S. Weather Bureau, Washington, D. C.

Paper: "Progress in the Correlation of Physics and Mathematics." Professor Frederick L. Bishop, Bradley Polytechnic Institute, Peoria, Ill.

* Published in the January number of this journal.

REPORT OF THE PROCEEDINGS OF THE CHEMISTRY SECTION OF THE C. A. S. & M. T. AT ITS FOURTH MEETING.

The Section was called to order by Chairman W. R. Smith, Friday, November 25, at 2 P. M. O. R. Flynn was appointed Temporary Chairman. The following program was given:

"Some Recent Advances in Chemistry," Dr. H. N. McCoy, University of Chicago.

"The Diminution in the Number of Students of Chemistry in the Secondary Schools, Its Causes and Its Remedies," Mr. O. R. Flynn, Hyde Park High School, Chicago; Principal J. E. Armstrong, Englewood High School, Chicago; Mr. F. B. Wade, Shortridge High School, Indianapolis.

Dr. McCoy was listened to with attention. The following is the substance of his remarks:

"The increasing tendency to study chemical problems by exact methods, based upon the rigid principles of chemical dynamics, was illustrated by a number of examples. These included: A study of the hydrates of nitric acid; the preparation and properties of crystalline nitrogen trioxide; the equilibrium between oxygen, nitrogen and nitric oxide at very high temperatures; the water gas problem; the stability of the complex cyanides; the autocatalysis of stibine and Stieglitz theory of electrification.

Among technical processes which have recently been practically perfected are the preparation of metallic calcium, the manufacture of artificial graphite, and the Goldschmidt process for the preparation of metals from their oxides by the use of metallic aluminium. Nitric acid is now being made from oxide of nitrogen, produced electrically from air.

In the field of organic chemistry the annual number of published researches is still greatly in excess of those in any other branch of the subject. Among many notable advances are Fischer's synthesis of diglycylglycin, a body which seems to be closely related to natural peptones, and Komppa's synthesis of camphoric acid and the confirmation of Bredt's formula for this body. The work on radioactive substances continues to be of surprising interest. The formation of helium by the spontaneous decomposition of radium, which was announced last year, has been fully confirmed. Evidence has also been found that radium is a decomposition product of uranium. Rutherford's experiments lead him to conclude that Hofmann's "radio-lead" and Marckwald's "radio-tellurium" are decomposition products of radium. J. J. Thomson's electron theory of the structure of the atom was presented briefly, and Ostwald's proposal to abandon the atomic theory was mentioned.

REMARKS BY H. N. GODDARD, OSHKOSH STATE NORMAL SCHOOL.

In connection with what has been said regarding the teaching of theory and the teaching of a large body of facts in chemistry in the

secondary school, I would like to add a word. It is easy to go to an extreme in either direction. Probably few would advocate the teaching of chemical theory pure and simple, without first trying to put the pupil into possession of a large body of facts from which to develop the theory. On the other hand, pure facts without any theory would result only in confusion. We shall probably find the best teaching somewhere between these two extremes. In using the word theory it seems needful to explain its meaning, as chemists perhaps use it sometimes in a technical sense, referring to the theory of molecular and atomic weights, chemical formulæ, etc. I wish to use the term here in the general sense, referring simply to the working out of an explanation of certain facts or phenomena. Now, as it seems to me, theory in this sense ought to be developed to a considerable extent in connection with facts all along the line from the very beginning. Any intelligent study demands the finding out of the reasons of things as far as possible. One of the best things that a teacher can do for a student, in my judgment, is to open up new lines of thought and give him an intelligent grasp of some interesting problem. Perhaps it may be months and even years before he will have a comprehensive grasp of the question, but it has found a place in his mind, and the very seeking for new evidence and completer understanding will be a mental training of the highest value. Multitudes of questions along any scientific line are but slightly understood, even by the specialist, and much less by the average teacher. Therefore my idea would be that while it would be easy to introduce theory prematurely and perhaps just as easy to go into abstractions which are beyond the comprehension of pupils, nevertheless thought should be aroused and an attempt should be made to formulate adequate explanations or theories in connection with all facts and phenomena studied.

Mr. Flynn took the floor to introduce the next topic. His remarks in substance were as follows:

Chemistry has been affected by the general change in high school programs in recent years.

Higher institutions have shown a tendency to discourage our favorite science by not requiring it as a qualification for entrance. Chemistry is distinctly worse off than physics in this respect. Not only this, but the chemistry teachers throughout the land have submitted to have chemistry placed in a situation subordinate to physics. The present tendency is to make physics a prerequisite to chemistry.

Chemistry is now taught as a fourth year study in many secondary schools which formerly offered it in the third year.

Admitting the fact of a decline and understanding the cause the natural inquiry is, "What can be done?" Believing in the elective system, we should simply ask that it be fairly applied, that no discrimination of college, normal school, or principal be allowed to operate in favor of any science, or against chemistry. Then, with a fair field and no favors, it

becomes the duty of the chemistry teacher to fit the study to the pupil, to make it truly educative, so that it may be a real educational unit.

Do not be satisfied with enunciating great principles and having them enunciated back, but measure the thing itself. Principles are principles of action. Their proper test is action. When you have taught, set a real problem requiring knowledge and skill for its solution. By the student's success in solving this problem you may judge of his knowledge and skill and in no other way.

This question was then taken up by Mr. Armstrong, of the Englewood High School, Chicago.*

Mr. F. B. Wade continued the discussion by reading the following paper:

The numerical facts as taken from the statistics of the United States Commissioner of Education are as follows:

Per cent of total students in secondary schools taking chemistry:

1890-91—Public High Schools, 10.20%; private schools, 10.60%; both, 10.37%.

1900-01—Public High Schools, 7.56%; private schools, 9.35%; both, 7.86%. It may be noted here that the figures for physics students show a slightly greater falling off. The decrease has been gradual throughout the decade.

This decrease may in part be due to a swing of the pendulum back to its normal position after an abnormal swing in the direction of the physical sciences. In so far as this is true no remedy need be prescribed. As a further explanation of the decrease in numbers I would call attention to the fact that many small high schools are wisely dropping chemistry, which they are poorly equipped to teach, from the list of subjects offered, preferring to teach a single science well, to attempting to teach several in an inadequate fashion. Physics is usually the science retained. This cause for the decrease is commendable and calls for no remedy.

A second specific cause is the increased freedom of election of studies which has marked the decade. Pupils who are no longer required to take chemistry avoid it because it requires double periods. That this is true is shown in our Indianapolis High Schools. At the Manual Training H. S. a majority of the pupils are boys. At the Shortridge H. S. a majority are girls. Boys are more likely to elect chemistry than girls, yet we have a much larger number of pupils in chemistry at the Shortridge H. S., where chemistry is required, than at the Manual Training H. S., where it is elective, although the latter school has a total attendance several hundred greater than that of the Shortridge H. S. This difference in the numbers in chemistry I believe to be due largely to avoidance of the two-hour period where the work is elective. Now, if it is worth while for every pupil to take chemistry the remedy is plainly to make at least one course in chemistry required work wherever the equipment is suf-

* Mr. Armstrong's paper is printed elsewhere in this issue.

ficiently good to warrant it. A third cause of the decline may, I think, be found in the fact that the teaching of chemistry is becoming more thorough and scientific. Chemistry as taught by the best teachers to-day cannot be considered a "snap" course. It is avoided wherever the elective system permits, because it requires a considerable amount of power to think and also requires some real study.

The remedy for this avoidance lies in making the teaching more attractive without lessening its efficiency in the least. The work may be made alive and intensely interesting to the average pupil by correlating it with the problems of daily life, with food and its proper cooking, with fuel and the smoke nuisance, etc. We may still teach the fundamental principles underlying the science and still make our teaching the medium for a drill in clear cut logical thinking without repelling the pupil by the use of illustrations remote from his experience. We must from time to time require him to perform quantitative experiments, but they should only be given to illustrate and clinch points in the argument, not just for the sake of giving a quantitative experiment. Where the pupil sees and fully comprehends their purpose he rarely finds them uninteresting. So also with problems. Nothing is more useful or interesting to the pupil when he sees the utility of the problem and nothing dryer when overdone or unrelated to the subject in hand. To further arouse interest and enthusiasm in the pupil much individual work must be done. Each pupil must have a little sympathetic personal attention from the teacher. Many a pupil has thus been put on the right track and there is no better way to steady down the wilful, mischievous lad than to interest him in something which, like chemistry, has the manual side well developed. By thus keeping the subject thoroughly alive and interesting, yet scientific, splendid work may be obtained and there will be no danger of a decrease in the numbers electing chemistry, nor will it be regarded as drudgery by those required to take it.

Mr. H. N. Goddard, of the State Normal School, Oshkosh, Wis., was recognized and spoke as follows:

This question seems to presuppose an acceptance at the outset of the proposition that chemistry merits a larger amount of time and consideration in the secondary schools than it now gets. Whatever opinion teachers of other subjects might hold, there is probably no ground for disagreement on this point among chemistry teachers. Certainly it would seem that the value of the subject was either small or else little appreciated when we consider that according to the last report of Commissioner Harris but 7.7% of the pupils in high schools and academies were studying chemistry in 1901. I think that we would all agree that the subject has large educational value. It is one of the three fundamental sciences which lie at the basis of the phenomena and principles of the pupils' physical environment. The subject possesses large value in the high school course, both because of its power to cultivate the scientific habit of mind

and because of the practical application it finds in the every-day phenomena and experiences of life.

Educational reports show, not only that chemistry and physics have been losing students in the last ten years in the secondary schools, but also that the subjects of Latin, rhetoric, algebra and geometry have made surprising gains in the last decade, and furthermore that all science lines have suffered like chemistry and physics. These facts, which apply to the whole United States, would seem to point to some far-reaching cause. Would it not seem to be true that there is a general reaction, still going on, away from the science subjects? If we accept the pendular idea of educational progress, we might regard this reaction as the normal change following the great science awakening which showed itself first in the universities and colleges and then a little later swept over the secondary schools within recent years. If this be true it seems to me that we may look with confidence toward a renewed awakening along science lines in due time, perhaps in the near future.

But, no doubt, there have been special causes which have acted in the same direction.

It has been stated that the introduction of commercial subjects, manual training, etc., have been drawing pupils away from science studies. Is it not true in a larger way that a generally overcrowded curriculum has led pupils, so far as they had any choice, to look for studies which have no laboratory work, or special experimenting connected with them, but require the pupils simply to be present at the recitation and leave them free to make preparation at their own convenience?

No doubt, too, the expense of equipping laboratories and constantly replenishing supplies has led to science subjects being either left out or later thrown out of many schools. My own observation is that chemsitry has suffered especially from this cause.

Again, it is undoubtedly true that competent science teachers are harder to secure and command higher salaries as a rule than teachers of other subjects. This has undoubtedly led to unsatisfactory work in many schools, or perhaps to the work being thrown out altogether in others, both of which results would decrease the number of students taking the work.

Then the point already made that the work had been made too largely theoretical and too much on the plan of university work is probably true to a large extent. The work, in my opinion, should be brought as near as possible to the common experiences of the pupils, so far as this is consistent with the development of the science of the subject. However, there seems to me a danger here into which some have fallen. In the attempt to make the work interesting and practical it has degenerated a mere fact or information study. The student is overwhelmed with facts which, though interesting at the time, are soon forgotten, unless they are organized about some unifying principle or principles which gives him an intel-

ligent grasp of the science which underlies the facts. When these principles have been indirectly worked out and understood in their relationships then a wide application to practical phenomena is desirable. Qualitative analysis as a beginning course in chemistry is an extreme form, as it seems to me, of this unwise application of the practical idea. So far as I know the general opinion of chemistry teachers is that this work as a beginning course has small value.

Dr. P. Radenhausen, of Davenport, Iowa, emphasized the ability of chemistry to stand alone without the support of a preliminary course in high school physics. He stated that it is taught as a second year study in his school.

Mr. Abells, of Morgan Park Academy, made remarks.

Dr. Alexander Smith was called upon to relate his experience with pupils having high school chemistry. He opposed the view that high school chemistry is of little advantage, stating that at the University of Chicago pupils presenting a chemistry credit are put in a class in which they do the equivalent of three major's work in two.

Saturday morning was devoted to the discussion of "What the Professional School Demands from the Secondary School in Chemistry."

Dr. Oldberg was the principal speaker. He said that the high school was now doing acceptable work and pupils presenting evidence of having completed the chemistry course in the Chicago High Schools are given credit for the introductory course. It is a great help to students who are intent on becoming familiar with chemical principles, to be allowed to prepare a great many compounds, notably the salts of the different acids. It is not always possible to keep laboratory and lecture work together, but in spite of that fact it is useful to keep the student employed in the laboratory the full time. He becomes familiar with the reagents and certain effects and lays the ground work for the understanding of chemical laws which are illustrated in the action of the reagents in question.

Remarks were made by Dr. A. L. Smith, Englewood High School, Chicago; Mr. C. M. Wirick, R. T. Clave High School, Chicago, and Harry D. Abells, Morgan Park, Ill., University of Chicago, Academy.

REPORT OF THE PROCEEDINGS OF THE MATHEMATICAL SECTION OF THE C. A. S. AND M. T.

The Mathematics Section of the Central Association of Science and Mathematics Teachers met in the Assembly Hall of the Northwestern Professional School Building, November 25, 1904, and was called to order by the chairman, Mr. C. E. Comstock, of the Bradley Polytechnic Institute, Peoria, Ill. Mr. H. E. Cobb, of Lewis Institute, read the paper of Mr. C. W. Sutton, of Cleveland, on "Some Problems Confronting the Leaders of Geometry."*

Prof. Greenwood, of MacKendell College, opened the discussion.*

* These papers will be published in a subsequent issue of this Journal.

Mr. Wright, of Cedar Falls, Iowa, questioned the introduction of construction first. He commended the idea of making out tables of tests of equality of angles.

Mr. Lennes, of John Marshall High School, Chicago, said: "We as teachers are too cocksure of ourselves in geometry. Geometry has suffered more from this attitude of teachers than from anything else." He deplored the method of teaching "limits," now in vogue.

Mr. Newhall, of Shattuck School, said: "Why can we not be satisfied with our definitions, if the pupils get from them a clear notion of the things described? The teacher should understand geometry critically, but such criticism confuses the work of the elementary pupil."

Prof. White, of Northwestern University, disapproved of the maxim of the paper that all propositions not bearing on subsequent work in the same course should be omitted. Many such propositions give pleasure and make the work interesting to the student.

Prof. Young, of the University of Chicago, said: "Even in college classes a vigorous discussion of limits is not remunerative. If we can make things plausible we are perhaps doing the best we can."

The second paper was read by Mr. C. W. Newhall, Shattuck School, Faribault, Minn., on "A High School Mathematics Club."

Mr. Donecker, of Crane Manual Training School, Chicago, showed a piece of apparatus—the algebraic equation balance—illustrating the equation. It makes concrete the operations in equations and also gives a visual representation of negative numbers, and operations, illustrates axioms, transpositions, laws of signs in multiplication, etc.

The section then adjourned.

Saturday, November 26, 10 A. M., Assembly Hall. Chairman Comstock presiding. The Committee on Nominations presented the following names:

For Chairman—H. E. Cobb, Lewis Institute, Chicago.

For Vice-Chairman—J. V. Collins, State Normal School, Stevens Point, Wis.

For Secretary—Miss Mabel Sykes, South Chicago High School, Chicago.

On motion the Secretary cast the ballot of the Section for the above officers.

The Section adjourned to a joint meeting with the Physics Section, when the following program was carried out:

Address: "The Introduction of Meteorology into the Course of Instruction in Mathematics and Physics,"* Prof. Cleveland Abbe, U. S. Weather Bureau, Washington, D. C.

Address: "Progress in Correlation of Physics and Mathematics,"† Professor Frederick L. Bishop, Bradley Polytechnic Institute, Peoria, Ill.

MRS. B. E. PAGE, *Secretary.*

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* Published in the January number of this Journal.

† To be published in a subsequent number of this journal.

EARTH SCIENCE SECTION OF THE CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS.

The Earth Science Section met Friday, November 25th, at 2 P. M., in Room A, fourth floor of the Northwestern University Professional School Building, Chicago. The officers of the section, Mr. C. E. Peet, of the Lewis Institute, Chairman, Miss Carrie Watson of the Elgin High School, Vice-Chairman, and Mr. E. Marsh Williams of the LaGrange High School, Secretary, had arranged for the program which follows.

The first speaker was Professor R. D. Salisbury, LL. D., Head Professor of the Department of Geography at the University of Chicago who delivered an address on "The Educational Value of Physiography." It is to be regretted that the instruction and the inspiration which those present derived from this address can not be extended to those not present by printing it in full, but inasmuch as it was not in manuscript form the following notes taken during the address must suffice:

The chief aim should not be to teach Physiography but to educate the student. To lead the student to intellectual independence is the greatest thing that can be done for him. Habits of thought are vastly more important than facts, which are not an end but a means to an end. The truth should be sought not for truth's sake simply, but truth should be sought for the use which may be made of it.

The study of Physiography should lead the student to a proper attitude toward study— to a receptive attitude, a recognition of his own limitations of knowledge. It should develop in him a sense of responsibility and should lead to the right methods of study. In common with other subjects it should lead him to think straight and to talk straight, to think on logical lines and to express himself clearly. Because the solution of many of its problems draws upon the fund of knowledge already accumulated through everyday experience Physiography is peculiarly well adapted to develop the habit of seeing the significance of things, of inferring causes from effects and consequences from causes.

The study of the subject should also put the student in appreciative relations with his surroundings. It should lead him to an interpretation of his home surroundings including the topography, the climate, and the industries, and to a greater appreciation of the beautiful things in nature because of a better understanding of their significance. It should give him large conceptions of things. In getting these large conceptions the imagination is stimulated. The contemplation of the great and the sublime expands the mind.

In accomplishing these ends judgment is required in the selection of the subject matter, in deciding where to place the emphasis, in deciding what to discuss fully, what to discuss partially, and what not to discuss at all. In the selection of subject matter judgment must be used in presenting work not so difficult as to discourage but difficult enough and enough of it to tax the student reasonably. Emphasis should be placed on

the fundamental things. Details that do not bear on the desired ends should be omitted. After the fundamentals the emphasis should be placed on those subjects the teacher is best qualified to teach. Among the important subjects are the distribution of temperature and the reasons, thus involving the motions of the earth and of the atmosphere, the distribution of moisture, the reasons for this distribution, and its effect on plants, animals, and man; the movements of the sea and their effects on temperature, on the life of the sea, and on the shore; the fundamental differences between plains, plateaus, and mountains, and their differences in temperature, moisture, life, and the differences in occupations of the people inhabiting them; the processes of change of these land forms and the inter-relations between these processes and temperature, moisture, and life. The history of the earth, the history of the sea and the history of the atmosphere belong to Geology, not to Physiography. Mineralogy should not be taught with the notion that it is Physiography.

The methods of presentation should be such as 1) to make the student think and think hard, 2) to reason accurately and quickly and 3) to express well. There should be enough recitation to show that the student has correctly interpreted what he has read, but if a student has mastered what there is in a book there is little value in having him recite it. The class-room hour should be the hour of the hardest work the student does. He should leave the class-room every day with the feeling that certain things have been clinched, that certain definite results have been attained, or that definite progress has been made toward this attainment.

It may be accepted as an important fundamental fact that the average student likes to work, that he likes to work out problems, and that it is worth more to him to solve one problem than to study a dozen solved by someone else. Students should be given problems continually (or, in the pedagogical terms of the present moment, "they should be made conscious of their problems") that will develop their power of originality. It is most desirable to get the students to see problems for themselves and to find ways for solving them. A topic may often be profitably introduced by a specific problem. The solution of problems insures mental digestion, for it forces the student to make use of facts to an end. An important class of problems is that which emphasizes the relations of things, as for example, the relation between high altitude and low temperature, the reasons therefor, and the relation between rainfall and winds, and between rainfall and vegetation. Another important class of problems includes those which will give the student a conception of large things, as for example, a calculation of the force involved in the making of mountains, or the effect on the land if wave action were continued forever.

Some other problems suggested were: 1. The factors determining the annual and the daily range of temperature respectively. For the solution of the former let the student get from maps the range in high, middle,

and low latitudes and then work out for himself the reasons for the difference. Let him get the range of temperature in the interior of high lands (such as North Asia) without perpetual snow, and also in the interior of high lands with snow (like Greenland) and then let him study out the reasons for the differences. 2. Why is the moon more efficient than the sun in producing tides? 3. Why is a degree of latitude longer at the poles than at the equator? 4. Is the atmosphere a part of the earth or an envelope? 5. What constitutes an impurity in the atmosphere?

The pupil may not be able to solve all these and other problems which should be assigned, but it will do him good to think about them. Even if he does not reach the proper solution his study of them prepares him to appreciate the solution. All problems must of course be carefully adapted to the stage of the pupil's advancement. The problems good for one class are not necessarily good for all.

Other profitable exercises are the translation of language into diagrams, or tables of statistics into diagrams and of diagrams into language, the making of definitions, not for their value after they are made, but for the profit in making them.

Synthesis should not be neglected. Analysis is not everything. It is a profitable exercise for instance, for the student to formulate a rule for finding the latitude from the altitude of the sun at an equinox, or at a solstice.

Such exercises as have been mentioned will lead the student to use facts from out of doors, from maps, charts, and diagrams, as well as from books. Enough reference books should be given the student for him to see that they do not always agree, and he should be led to see that the reading of books is not the only source of information and not always the most important source. The student should be brought to understand by practice rather than by precept that much good studying is altogether independent of books.

In every topic it is important that a conclusion be reached, that it be left definitely certain or definitely uncertain. If left with ragged ending and no conclusion the student is likely to think, and with some reason, that it was not worth while.

The second speaker was Miss Marion Weller of the Northern Illinois State Normal School, who read a paper on Clay Modeling and Chalk Modeling an Aid in Expression in Physiography, which was illustrated by several examples of the chalk modeling.

Mr. E. Marsh Williams spoke on the construction of Papier Maché models. Several finished models and the materials for their construction were shown. The latter included cardboard, carbon paper and pantograph for tracing the lines, thin bladed knife and chisel for cutting the cardboard, glue and nails for fastening the cards together after they had been cut to the proper shape, paper pulp to make a smooth surface over the cardboard model and paint for a finishing coat. The models exhibited

were of two classes—those showing in relief features represented by topographic maps and those showing in relief the high pressure and low pressure areas represented on the weather maps. The latter were constructed on outline maps of the United States and represented the high pressure areas as elevations and the low pressure areas as depressions, thus showing graphically (1) the difference in pressure between the "Highs" and "Lows," (2) the barometric gradient and its relation to the spacing of the Isobars, (3) the relation of the direction and velocity of the wind to the barometric gradient. Attention was called to the value of a series of such models showing the advance and changing characteristics of these cyclonic and anti-cyclonic areas. In the discussion which followed it was suggested that if the material for representing the "Highs" and "Lows" were transparent and were to be placed over the outline map it would be an improvement.

On motion of Mr. W. S. McGee of the Hyde Park High School the section voted for the appointment of a committee to arrange for the exchange of illustrative materials. The appointment of the committee was left to the officers for next year.

The paper by Mr. Willard S. Bass of the Francis W. Parker School, Chicago, on Topographic Surveying for the Ninth Grade was illustrated by the instruments used in the surveying. It will be published in full in the March number of this journal.

In the evening after the dinner at Hull House, under the escort of Mr. E. Marsh Williams and through the courtesy of Professor Hough of the Dearborn Observatory, Evanston, members of the section who so desired paid a visit to the observatory and enjoyed the privilege of inspecting the equipment and taking a look through the 15-inch refractor.

Saturday morning the section adjourned after the election of officers to hear the address by Professor Cleveland Abbe before the mathematics section on "The Introduction of Meteorology into the Course of Instruction in Mathematics and Physics." This paper was published in the January number of this journal.

On re-assembling the section had the privilege of listening to the very instructive paper by Professor Henry J. Cox, of the United States Weather Bureau, Chicago, on "Recent Advances in Meteorology," which is published in this issue of School Science and Mathematics. The paper was followed by an extended and profitable discussion.

Mr. L. Lester Everly, spoke of the "United States Geological Survey Illustrative Material" as follows:

The desirability of securing copies of the photographs taken by the U. S. Geological Survey has led to an investigation of the matter with the following result. There seems to be at present two means by which these pictures may be secured.

First. A number of unusually clear and pertinent prints from the photographs are to be found in some of the Geologic Folios, of which over

one hundred are now issued. Most of these folios sell for twenty-five cents each and contain from six to twelve or more pictures up to 5x7 inches in size, thus furnishing photographs at 2 to 4 cents each. Of these folios the following are possibly the most useful:

1. La Plata, Col., mountain forms and valleys.
2. Telluride, Col., glacial valleys, mature erosion.
3. Lassen Peak, Calif., cinder cone, lava flows, Mt. Vesuvius.
4. San Luis, Calif., sea cave, shore forms, contorted shale.
5. Chicago, Ill., (50c) glaciated bed rock and bowlders, sand dunes.
6. Texas Topographic Atlas (50c), mesas, cliffs and flood plain.

These illustrations cut from the folios and mounted become valuable aids.

Second. The other source consists of some 1,400 photographs which are the property of the Geological Society of America. Details of these may be learned by securing, from the society or some library, Bulletin of Vol. 13 entitled "A catalogue of Photographs belonging to the Geological Society of America. Pages 377—474. Compiled by N. H. Darton." The date of the bulletin is Dec. 3, 1902. This may be secured as a separate from the volume, the price being $1.10 to members and $2.20 to non-members. The address of the society is Rochester, N. Y.

About two-thirds of these photographs have been secured by members of the U. S. G. S., the remainder by other members of the society. These 1,418 negatives have been selected with great care from an original collection of over 2,000. They are catalogued first by states, the title, photographer, and size of negative being given, and afterwards catalogued by subjects. They vary in price when unmounted from 8 cents for the 4x5 size up to 30 cents for the 11x14 size, or may be secured already mounted for 2 to 5 cents extra. Some very large views have special prices. They may be ordered in the form of lantern slides at 50c each or at 45c when in lots of over 100. Apply to the Director of the U. S. Geological Survey at Washington, D. C.

Mr. C. S. Jewell of Lake View High School, Chicago, submitted for examination a large collection of "Helpful Advertising Matter" in the way of railroad pamphlets, pictures, and maps, which were the result of some years of watchful collecting. It was judged best not to publish the list but those who desire it may obtain this list from Mr. Jewell.

At a late hour the section adjourned for lunch and on the cordial invitation of Professor Cox later in the day paid a visit to the Chicago office of the Weather Bureau.

The officers of the section for the next year are as follows: Chairman, Mr. James A. Smith of the Austin High School, Chicago; Vice-Chairman, Miss Marion Weller of the State Normal School, DeKalb, Illinois; Secretary, L. Lester Everly of Wendell Phillips High School, Chicago.

SCIENCE AND MATHEMATICAL SOCIETIES.

Under this heading is published each month the name and officers of such societies as furnish this information.

Central Association of Science and Mathematics Teachers.

President, Otis W. Caldwell, State Normal School, Charleston, Ill.
Secretary, Chas. M. Turton, 440 Kenwood Terrace, Chicago, Ill.
Treasurer, E. Marsh Williams, High School, La Grange, Ill.

Annual meeting Friday and Saturday immediately following Thanksgiving.

Chicago Center, C. A. S. and M. T.

President, W. C. Hawthorne, Central Y. M. C. A., Chicago.
Vice-President, P. B. Woodworth, Lewis Institute, Chicago.
Secretary, C. E. Osborne, High School, Oak Park, Ill.

North-Eastern Ohio Center, C. A. S. and M. T.

President, Franklin T. Jones, University School, Cleveland.
Vice-President, Miss Winona A. Hughes, High School, Mansfield, Ohio.
Secretary-Treasurer, Clarence W. Sutton, Central High School, Cleveland.

Eastern Association of Physics Teachers.

President, George A. Cowen, W. Roxbury High School, Jamaica Plain, Mass.
Vice-President, Irving O. Palmer, Newton High School, Newtonville, Mass.
Secretary, Fred R. Miller, English High School, Boston, Mass.
Treasurer, Arthur H. Berry, Classical High School, Providence, R. I.

Natural Science Association. A section of the Ontario Educational Association.

Hon. President, T. L. Walker, Toronto, Ont.
President, T. H. Lennox, Stratford, Ont.
Vice-President, S. B. McCready, London, Ont.
Secretary-Treasurer, E. L. Hill, Guelph, Ont.

Annual meeting, Toronto, Tuesday, Wednesday and Thursday of Easter week.

Indiana Science Teachers' Association.

President, N. H. Williams, Terre Haute.
Vice-President, M. T. Cook, Greencastle.
Secretary, W. H. T. Howe, Indianapolis.
Treasurer, J. F. Thompson, Richmond.

American Physical Society.

President, Carl Barus, Brown University, Providence, R. I.
Secretary, Ernest Merritt, Cornell University, Ithaca, N. Y.

Association of Ohio Teachers of Mathematics and Science.

President, Charles S. Howe, Case School of Applied Science, Cleveland.
Vice-President, Alan Saunders, Hughes High School, Cincinnati.
Secretary, Thomas E. McKinney, Marietta College, Marietta.

Science Section.

Chairman, Will G. Horwell, Ohio Wesleyan University, Delaware.
Secretary, Jacob W. Simon, Woodward High School, Cincinnati.

Pacific Coast Association of Chemistry and Physics Teachers.

President, S. E. Coleman, High School, Oakland, Cal.
Vice-President, James McIntosh, High School, Stockton, Cal.
Secretary-Treasurer, Edward Booth, Dept. of Chemistry, University of California.

National Educational Association.

President, William H. Maxwell, Supt. of Schools, New York City.
First Vice-President, John W. Cook, Prin. State Normal School, DeKalb, Ill.
Treasurer, James W. Crabtree, Peru, Neb.
Secretary, Irwin Shepard, Winona, Minn.

Association of Teachers of Mathematics in the Middle States and Maryland.

President, David Eugene Smith, Teachers' College, Columbia University, New York City.
Vice-President, H. B. Fine, Princeton University, Princeton, N. J.
Secretary, Arthur Schultze, High School of Commerce, 4 W. 91st St., New York City.

EXPLANATION.

Owing to unexpected circumstances the former editor of School Science was unable to publish the editions for October, November and December in 1904. Paid up subscriptions, therefore, to either School Science or School Mathematics are extended to cover this period.

The present publishers of School Science and Mathematics propose to issue the magazine on the first of each month from October to June inclusive. Material to appear in any number must be in the Editor's hands not later than the *10th of the month* immediately preceding.